SCIENCE

10 October 1958

Volume 128, Number 3328

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This beautifully illustrated *new* text gives the student a clear understanding of modern zoology. Its unique presentation of vertebrates and invertebrates emphasizes anatomy, habitat and mode of life. General concepts basic to the study of form and function are clearly explained at the beginning of the book. Each invertebrate phylum is featured in a separate chapter including a detailed study of one or more representative species. The presentation of each phylum concludes with a survey of its classes and major orders.

The vertebrates are introduced with a detailed consideration of the frog as a representative chordate. A history of the vertebrates provides an introduction to the morphology and physiology of the several organ systems. Evolution, genetics and ecology are clearly discussed. *Gladly sent to college teachers for consideration as a text.*

By CLAUDE A. VILLEE, Harvard University; WARREN F. WALKER, JR., Oberlin College; and FREDERICK E. SMITH, University of Michigan. 877 pages, 6" x 9¼", with 444 illustrations. $7.50. *New!*

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The first section of the manual surveys the animal kingdom and includes all the "Classical" animals necessary to a beginning course in zoology. The second part is devoted to the comparative anatomy of organ systems with special emphasis on the frog.

Though designed to closely follow *Villee-Walker-Smith's General Zoology,* it can be used effectively with any zoology text.

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By HARVEY I. FISHER, Ph.D., Chairman, Department of Zoology, Southern Illinois University; and JAMES B. KITZMILLER, Ph.D., Chairman, Department of Zoology, University of Illinois. 227 pages, illustrated. 8½" x 11". $4.00. *New!*

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Prepared by WILLIAM O. NEGHERBON, Ph.D., under the Direction of the Committee on the Handbook of Biological Data, National Research Council. About 830 pages, 8½" x 11", 2 volumes. About $12.00. *Just Ready!*

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WILEY — BOOKS

THE GENETIC BASIS OF SELECTION

By I. MICHAEL LERNER, *University of California, Berkeley.* This book is designed for the reader who has been thoroughly trained in modern genetics but lacks an extensive background in mathematics and statistics. It is devoted primarily to the diploid sexually reproducing population. Dealing in detail with the intraspecific level of biological organization, the book places greater emphasis on artificial selection rather than natural selection. Examples, forming the core around which the book is written, are devoted to experimental data on the domestic fowl. The book stands at mid-point between the romantic and the traditionally accepted positions on selection. All data cited are used to illustrate ideas and not to show precise quantitative relations. *1958. 298 pages. $8.00.*

MARINE ECOLOGY

By HILARY B. MOORE, *the Marine Laboratory of the University of Miami and the Woods Hole Oceanographic Institute.* Gathering together pertinent material which has been dispersed throughout journals and general ecological studies, this book reviews and coordinates existing information on marine sciences. Included is a survey of various subjects relating to the study of marine ecology. *1958. 493 pages. $9.50.*

OUTLINES OF ENZYME CHEMISTRY
Second Edition

By J. B. NEILANDS, *University of California, Berkeley, and* PAUL K. STUMPF, *University of California, Davis.* This new edition incorporates recent developments in the field and presents the whole of enzyme chemistry in easy-to-read outline form. The authors include a catalog which provides data on the general characteristics of over 500 enzymes. *1958. 411 pages. $8.50.*

PHYSICAL CHEMISTRY OF HIGH POLYMERS

By MAURICE L. HUGGINS, *Eastman Kodak Company, New York.* The book is aimed at the reader interested in working with synthetic polymers, textile fibers, rubber, proteins, and plastics. The author extends the concepts of classical chemistry to systems containing large molecules and describes the molecular structures of both synthetic and natural high polymers. *1958. 175 pages. $6.50.*

CHOLESTEROL

By DAVID KRITCHEVSKY, *The Wistar Institute and the University of Pennsylvania.* This book provides a centralized source of information on the biological function and significance of cholesterol. With pertinent material from chemical and medical literature, the book covers cholesterol chemistry, biochemistry, and physiology, and provides a background for future investigation. *1958. 261 pages. Illus. $9.75.*

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By C. KITTEL, *University of California, Berkeley.* For the experimental or theoretical physicist, this book offers a clear fundamental treatment of statistical mechanics, and includes material on stochastic processes and transport theory. There is also material on the thermodynamics of irreversible processes and fluctuations. A wide coverage of applications of physical interest. *1958. 228 pages. Illus. $8.00.*

THE INFRA-RED SPECTRA OF COMPLEX MOLECULES
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By L. J. BELLAMY, *Ministry of Supply, U.K.* A thoroughly revised and expanded review of the data on which infra-red spectral correlations are based. Also indications of the classes of compounds which have been studied and the known factors influencing the frequencies or intensities of the characteristic bands. *1958. 425 pages. $8.00.*

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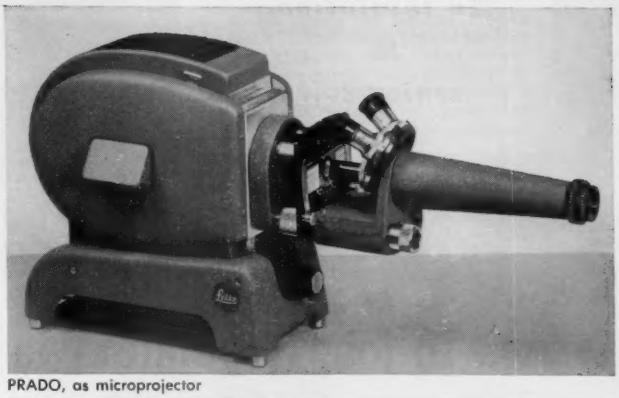

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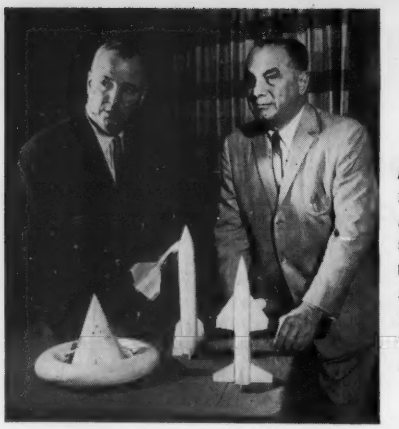

A $14,000,000 R & D Center, housing 9 new laboratories, was revealed as core of Republic's $35,000,000 Research and Development Program at recent announcement by Mundy I. Peale, President, and Alexander Kartveli, Vice-President for Research and Development.

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In announcing Republic's $35 million research and development program, designed to arrive at major breakthroughs in the aviation industry's transition to astronautics, Mundy I. Peale, President, set the following objectives:

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Alexander Kartveli, Vice-President for Research and Development, emphasized that Republic's program "will not duplicate in any way investigatory work currently in progress elsewhere, but will stress novel concepts and new approaches to basic problems of missiles and space technology."

The program includes construction of a $14 million R & D center to house 9 new laboratories, and anticipates doubling the present research staff.

Senior men interested in the new possibilities created by a simultaneous exploration of all aspects of Flight Technology are invited to study the functions of the new laboratories for more detailed information:

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MATERIALS DEVELOPMENT LABORATORY
Study effects of high velocity, temperature, and space environment on materials for spacecraft, missiles and advanced weapons.

GUIDANCE & CONTROL SYSTEM DEVELOPMENT LABORATORY
To develop and test guidance and control systems for spacecraft, missiles and aircraft.

ELECTRONICS DEVELOPMENT LABORATORY
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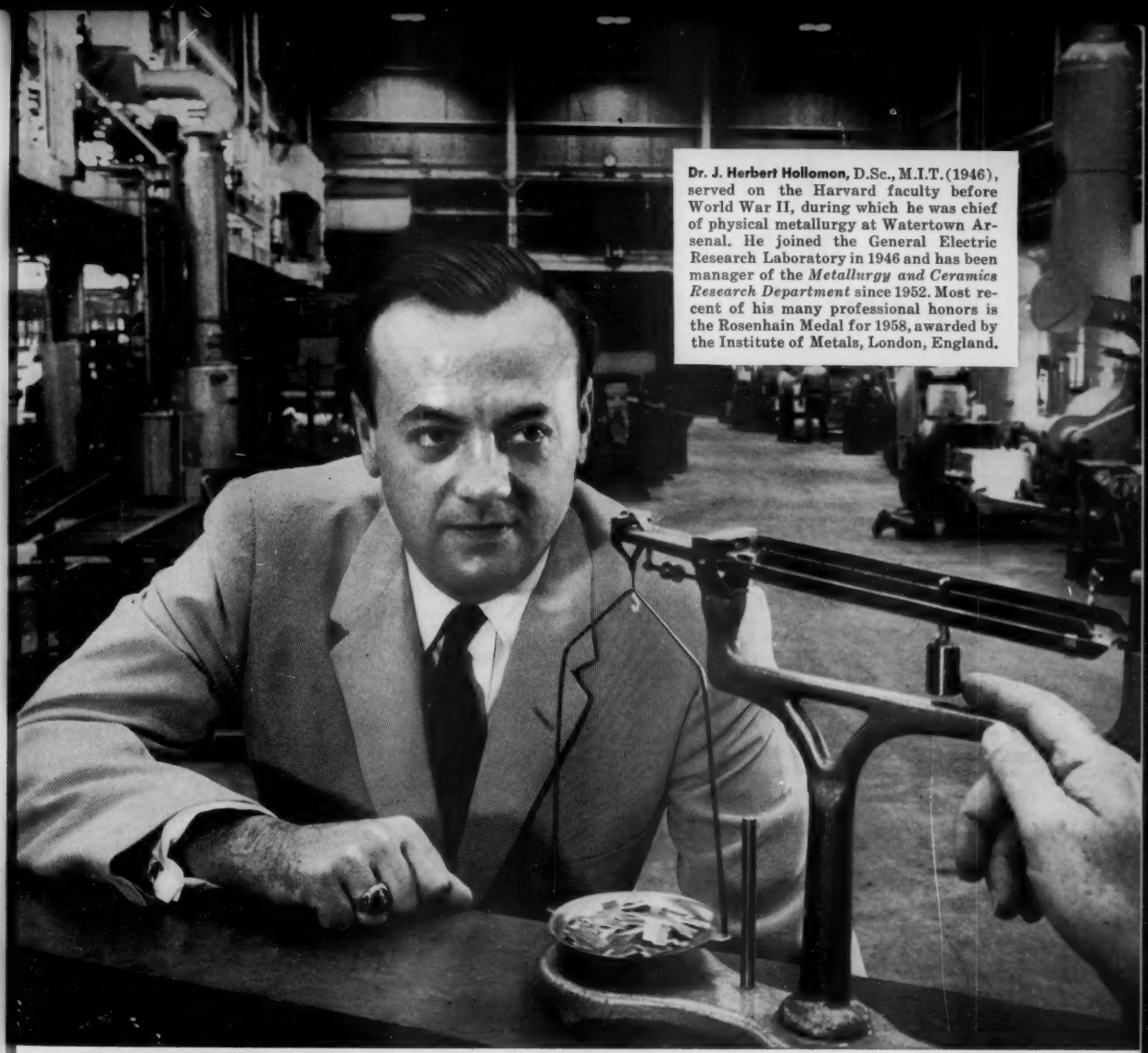

Dr. J. Herbert Hollomon, D.Sc., M.I.T. (1946), served on the Harvard faculty before World War II, during which he was chief of physical metallurgy at Watertown Arsenal. He joined the General Electric Research Laboratory in 1946 and has been manager of the *Metallurgy and Ceramics Research Department* since 1952. Most recent of his many professional honors is the Rosenhain Medal for 1958, awarded by the Institute of Metals, London, England.

Materials to match ideas

General Electric's Dr. J. Herbert Hollomon cites need for "materials scientists" and "materials engineers"

For centuries, when inventive men came up with unique and useful ideas, there was almost always something available from which a practical device could be made. But recently, man's brain has begun to outrun the available materials. He could design and build faster planes, safer cars, improved missiles—*if* there were better materials.

Dr. J. Herbert Hollomon, one of the leaders of a group of outstanding scientists at the General Electric Research Laboratory, believes the problem can be solved only by taking a much broader view of *materials research and development.*

"From a scientific standpoint," says Dr. Hollomon, "the science that underlies the behavior of metals, ceramics, semiconductors, or polymers is essentially the same. And the design engineer — for whatever product — wants *the best material for the job.* He is not concerned whether the material is metallic, ceramic, plastic, or made of green cheese."

Dr. Hollomon looks to the day when universities will produce topflight materials scientists and materials engineers for important jobs in tomorrow's world. "The closer interaction of physics, electronics, chemistry, metallurgy, and ceramics," he says, "will strengthen the nation's defense, extend the capabilities of American industry, and improve the level of living for people everywhere."

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Program content

1. The two-session general symposium, "Moving Frontiers of Science III: The Structure of Science and Scientific Organizations Abroad," arranged by the Committee on AAAS Meetings.
2. The six sessions of the Conference on Scientific Communication Problems.
3. Programs of the 18 AAAS sections (symposia and contributed papers).
4. Programs of the more than 90 participating societies.
5. The Special Sessions: AAAS, Academy Conference, Conference on Scientific Manpower, National Geographic Society, Phi Beta Kappa, Sigma Xi, RESA.
6. Details of the Sheraton-Park Hotel—center of the Meeting—and of the other hotels and session sites.
7. Titles of the latest foreign and domestic scientific films to be shown in the AAAS Science Theatre.
8. Exhibitors in the 1958 Annual Exposition of Science and Industry and descriptions of their exhibits.

Directory content

1. AAAS officers, staff, committees for 1958.
2. Complete roll of AAAS presidents and their fields.
3. The 279 affiliated organizations.
4. Historical sketch and organization of the Association; the Constitution and Bylaws.
5. Publications of the Association.
6. AAAS Awards—including all past winners.
7. Membership figures by sections.
8. Section committees (Council members) in detail.
9. Local committees.
10. Future Meetings of the AAAS through 1962.
11. New and current activities of the AAAS.

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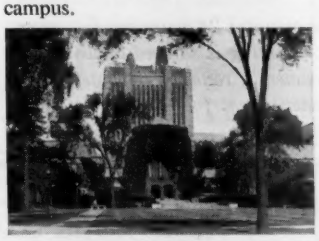
Finding ourselves in mid-20th century, we have to proceed toward these simple objectives by sophisticated routes. We use more than mere words for persuasion. We employ graphic communication. From the Yale News Bureau, we acquire a photograph of their serene campus.



We assure the Bureau that no endorsement of us or our works is to be implied. The photograph serves only as a visual symbol of scientific objectivity.

Next we establish why we picture Yale instead of some other equally serene haven of objectivity. Yale was the site of two important conferences at which learned psychologists and successful communicators met and scrutinized the obstacles to wider and wiser use of films, slides, sound filmstrips, etc., in conveying information, skills, or attitudes from one group of heads to another.* A second Yale angle is that two of its professors of psychology have prepared a scholarly evaluation of scientific principles for maximum learning from motion pictures and other audio-visual media. In the native patois of their discipline they say that movies are fine for teaching and suggest lines of research on how to improve them even further than they have already been improved by all the research they cite.

Their views and those of the conferees are given in a book entitled "Graphic Communication—and the Crisis in Education," obtainable from the Department of Audio-Visual Instruction of the National Education Association, 1201 16th Street, N.W., Washington 6, D.C. We suggest the hard-cover edition at $2. It makes just the right noise when slapped down at the opposite end of the table from any finance committee member who insists on something scientific that he can take home in his briefcase.

Monkshood and delphinium

Striving to make conversation, we closed our eyes and opened "Eastman Organic Chemicals List No. 41." Our blind finger fell on Eastman 7381, *7-Ethyl-3,4-dihydro-1-(2H)-naphthaleneone*, bottom of p. 106. That would do. We looked up the records, and off went a letter to S. W. Pelletier of the Rockefeller Institute for Medical Research inquiring to what purpose he had had us prepare this compound. His response came by return of post.

Monkshood is like a wild delphinium. Beware. In man, the lethal dose for the aconitine from its leaves and roots is 2 to 3 mg. In ancient times this extract was used for arrow poison and for relief of hypertension, gout, and rheumatism. Absorbed through the mucosa or skin, it produces intense tingling and warmth, then peripheral anesthesia. On the central nervous system its effect is stimulation of the medullary vagal centers and slowing of the heart rate. "Is that so?" was once the appropriate next question. Intellectual fashions change. Today the proper question is "Why?" You want to know the molecular machinery.

In the middle of 1957, Pelletier put a young post-doctorate to work synthesizing a certain $C_{16}H_{15}N$ base which comprises all but six carbons of the atisine skeleton, one of the simpler aconitine alkaloid structures present in monkshood and delphinium. Duplication of the postulated molecule required a 14-step synthesis. Producing only 50 grams of the 4th step product took a week. Figuring the probable attrition in cul-de-sacs along the rest of the route, Pelletier wanted at least 500 grams at the end of the 4th step. Whereupon he thought of us. No strain here. Whereupon the 14-step synthesis shrank to a 10-step synthesis, with plenty of Eastman 7381 left over for others interested in monkshood and delphinium.

Dr. Pelletier can now unequivocally state [*J.A.C.S.*, *80*, 2588 (1958)] that the $C_{16}H_{15}N$ base is 1-methyl-6-ethyl-3-azaphenanthrene. He also states, "I might add that the success of this work is due in no small measure to Eastman's supplying this material quickly and at a reasonable cost."

By "Eastman" he means Distillation Products Industries, Eastman Organic Chemicals Department, Rochester 3, N. Y. (Division of Eastman Kodak Company). Perhaps you, too, would like a free copy of List No. 41.

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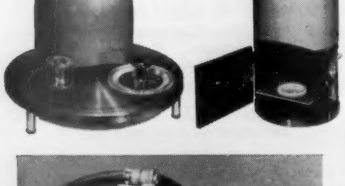

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The New Mathematics

A listing of curriculum studies in mathematics of this decade, which have attracted national attention, would involve no less than a dozen entries. Considerable information is already available on the work of the Commission on Mathematics of the College Entrance Examination Board, the Committee on the Undergraduate Program of the Mathematical Association of America, and the University of Illinois Committee on School Mathematics. Among the others, more information will be available soon on the work at Ball State Teachers College and the University of Maryland.

In the summer of 1958 the School Mathematics Study Group (SMSG) received its initial support from the National Science Foundation. Directed by E. G. Begle, recently secretary of the American Mathematical Society, SMSG started its activities at Yale University with a writing group of 40 persons made up of top-level research mathematicians and secondary-school teachers. SMSG is in an excellent position to make use of what has been learned in the earlier studies and thus to resolve some of the concern about different points of view within the mathematical community. Although during this year SMSG will concentrate primarily on grades 7 through 12, this broadly conceived national study provides for a more extended view of mathematics education at all levels of instruction than has been possible in any of the other studies. Its plan to involve college and university mathematicians in all parts of the country working in their own regions as well as on national teams should enable SMSG to have the cooperation of many mathematicians and their colleagues in other sciences.

Mathematics plays a special role in a society which is changing at an accelerating pace. For this reason the task of revising the school programs in mathematics is extremely urgent and requires a massive effort on the part of mathematicians, teachers, and school administrators. Since it is impossible to predict what a child will need to know in his adult life, and since the nature of his vocation can be expected to change with increasing frequency, the main emphasis in education must be placed on methods of obtaining knowledge, rather than upon fixed bodies of information. The deductive method—and mathematics is the science of deductive reasoning—is one of the principal tools for obtaining knowledge. A person needs to understand mathematical methods and language in order to use the accumulated knowledge and newly discovered results of the physical, biological, and social sciences and to apply them to engineering, or medicine, or the making of social policies.

The mathematicians believe, with justification, that mathematics is worth studying for its own sake. But modernization of the mathematics curriculum not only benefits mathematics, it also benefits science. To quote Courant: "The regained internal strength and, above all, the enormous simplification attained on the basis of clearer comprehension make it possible today to master the mathematical theory without losing sight of applications." In their search for better ways of leading students to an understanding of mathematics, enjoyment in their study, and greater achievement in school, mathematicians serve science well indeed.

Cooperation of mathematicians with engineers and social scientists has already led to the preparation of recommendations on college mathematics courses, issued by the American Society of Enginering Education and the Social Science Research Council. AAAS conferences on mathematics instruction, held in 1956–57, brought together some 300 mathematicians, scientists in the other fields, and teachers representing all levels of instruction to consider and advise on the curriculum studies. Perhaps another conference of this kind would be desirable. Also through SMSG there are now ways of promoting this cooperation so important for science education.

There is just cause for optimism among scientists because of the great effort now being made to improve mathematics education.—J.R.M.

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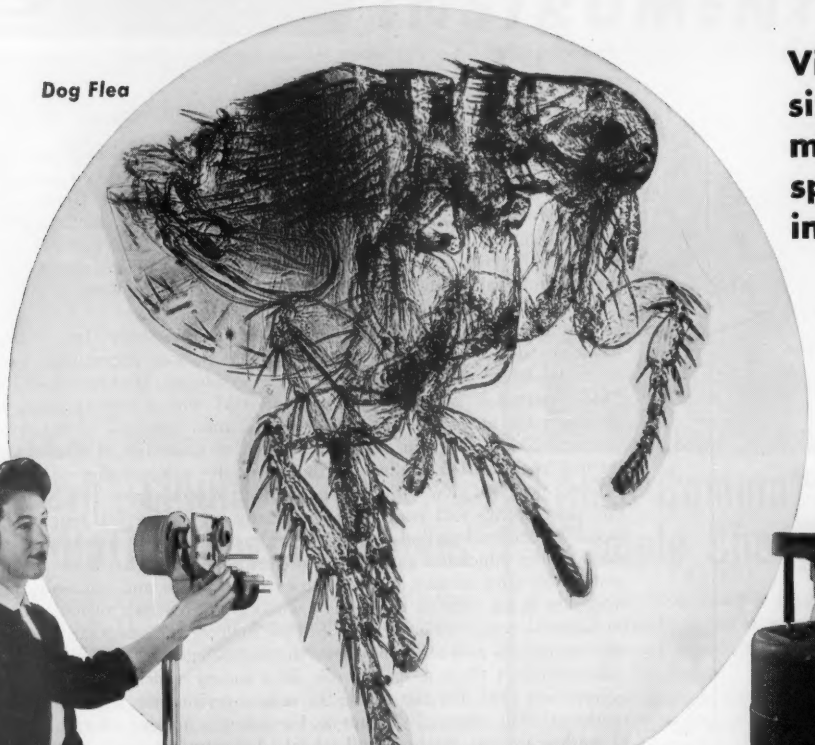

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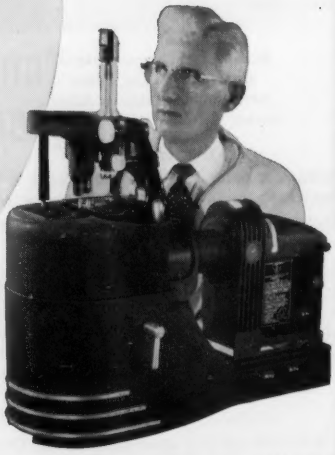

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CURRENT PROBLEMS IN RESEARCH

Atmospheres of Other Planets

Much has recently been discovered about the atmospheres of the planets, but some puzzles remain.

Seymour L. Hess

The study of planetary atmospheres requires the joint efforts of scientists from many fields. Since the data must be gathered largely by telescopic means, astronomers play a dominant role. However, a cool planetary atmosphere with a solid surface below and clouds within is by no means so simple an object for study as a very hot, completely gaseous star. The methods of astrophysics, however successful with stellar and nebular problems, are not often adequate here. The history of serious planetary study is therefore marked by contributions, albeit too infrequent, from chemists, physicists, meteorologists, and biologists.

Although there are eight other known planets in our system, there is no need to discuss all of them here. Mercury is essentially devoid of atmosphere; Saturn, Uranus, and Neptune so closely resemble Jupiter that we need discuss only the latter; and Pluto is so distant that virtually nothing is known of its atmosphere. I shall, therefore, deal only with Venus, Mars, and Jupiter. We shall see that physical conditions and the nature of the atmospheres of these three vary so greatly that each represents a unique scientific puzzle. Some of the pertinent physical data on these planets are given in Table 1.

Venus

Telescopic study of Venus is complicated by that planet's position between our orbit and the sun. When Venus is closest to Earth, and therefore presents its maximum angular diameter, most of the planet is in shadow and only a thin illuminated crescent can actually be seen. When Venus is on the opposite side of the sun from us we have the advantage of seeing the full phase, but then the angular diameter is small because of the great distance of the planet. This unfortunate situation is only the first of several frustrating facts which make the study of Venus difficult.

That Venus has an atmosphere was known long before any spectroscopic evidence of the composition of its atmosphere was produced. In the absence of an atmosphere it is possible to calculate the extent of the thin crescent phase from purely geometrical and astronomical considerations. Direct observation shows clearly that the illuminated crescent of Venus, unlike that of our moon, extends much further than one would expect. Figure 1 shows a direct photograph in which the crescent of light extends around the planet to form a complete ring. This can only be due to refraction and scattering in an atmosphere.

Aside from mere speculation, nothing was known of the composition of this atmosphere until 1932, when Adams and Dunham (*1*) of the Mount Wilson Observatory recorded the spectrum of Venus near 8000 angstroms, using high dispersion and a new fast photographic emulsion. They recorded two new absorption bands, with heads at 7820.2 and 7882.9 angstroms and detectable line structure. Since virtually no laboratory spectra of common gases had been recorded then in this part of the spectrum, it was not possible to identify the responsible gas by direct comparison. Instead, Adams and Dunham measured the positions of the constituent lines of the bands and calculated the required moment of inertia of the unknown molecule. The result agreed closely with the known value for CO_2. To complete the identification, Adams and Dunham set up a long metal pipe, sealed with glass windows at the ends, and then filled the pipe with CO_2 at high pressure. The spectrum of light passing through this massive amount of gas exhibited an absorption band at the same wavelength as one of those observed for Venus, thus completing the identification. This must surely be regarded as a notable and elegant combination of theory and experiment to achieve scientific truth.

Herzberg (*2*) has studied these absorptions of CO_2 in the laboratory, using a multiple-reflection absorption tube which permits very long effective pathlengths with low pressure. This is important since the bands involved vary in intensity with pressure even when the total amount of gas in the path is kept constant. Herzberg found that the strength of the planetary absorption is matched in the laboratory by that of a column of CO_2 1000 meters long at a pressure of 760 millimeters of mercury and a temperature of 0°C. Since the Earth has but 2 meter-atmospheres of CO_2, the amount on Venus is 500 times larger than our own.

No other gases have been identified positively in the atmosphere of Venus. Adams and Dunham have searched for O_2 and H_2O absorptions at a time when the relative radial velocity of Venus and Earth was large. Because of the Doppler effect, the Venusian lines are then shifted slightly from the positions of the terrestrial lines and may be detected despite the interference of the Earth's oxygen and water vapor. Visual inspection of

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these spectrograms revealed no noticeable absorptions by the atmosphere of Venus, and Adams and Dunham estimated that the planet has less than 5 percent of the terrestrial amount of these gases. This limit can be refined much further, and possibly a positive identification may be obtained, if such high-dispersion spectra are measured photometrically for asymmetries in the terrestrial line profiles. Such asymmetries will be produced by relating small amounts of O_2 and H_2O whose absorptions have been displaced by the Doppler shift. This matter cannot be considered closed.

Emission features in the spectrum of the dark side of Venus have been recorded (*3*) which coincide with the positions of known bands of the singly ionized nitrogen molecule in the airglow of our own night sky. These emissions are more intense than those from our own night sky and strongly imply the existence of appreciable amounts of nitrogen on Venus. The question has been raised (*4*) whether this is not due to scattering of light from Venus by the N^+_2 in our own upper air. Furthermore, other molecules may emit at similar wavelengths. These doubts will have to be resolved, and the observation will have to be verified before its implications can be accepted without reservation.

Thermal Data for Venus

Temperatures have been determined by a variety of means. From a measurement of the infrared energy arriving from the planet it is possible to calculate the temperature of a black body which would emit at this rate. Three independent sets of such radiometric estimates (*5*) agree that the radiometric temperature is near −38°C for both the dark and sunlit parts of Venus. This is surprisingly low compared with terrestrial temperatures and remarkably independent of night and day. The presence of large amounts of CO_2 permits us to understand these results because a large proportion of the infrared energy from the visible surface (around 10 microns and 13 microns) cannot escape to space but is absorbed by the overlying CO_2 and re-emitted at a rate determined by the temperature of the overlying atmospheric layers. Thus, −38°C applies to some layer relatively high in the atmosphere of Venus, not to the surface. From terrestrial experience, we expect the upper atmosphere to have a smaller diurnal temperature variation than the surface, but even so the diurnal uniformity of the radiometric temperature implies a vigorous convective circulation which transports large amounts of heat from the day to the night hemisphere.

The photographic infrared bands of CO_2 (around 0.8 micron) are intrinsically weak and require large amounts of the gas for their development. As a result, these absorptions take place primarily in the dense lower atmosphere, in contrast to the strong radiometric emission bands which are developed at a higher level. The envelopes of the photographic bands are due to vibrational transitions, while the line structure of each band is the result of rotational transitions in the CO_2 molecule. But the populations of the various rotational energy levels are determined by the gas temperature, so it is possible to estimate the temperature of the absorbing layer from the distribution of intensity among the lines. Adel's original calculations (*6*) based on this idea gave a temperature greater than 50°C. Subsequent investigators have found values ranging from 16° to 27°C, with an uncertainty of tens of degrees. These results are definitely higher than the radiometric values and lend support to the idea expressed above that temperature decreases with height in the atmosphere of Venus, as it does in the major part of the Earth's atmosphere, and that the 10-micron radiation is largely from CO_2 at a high level.

Very recently (*7*) the intensity of radiation at a wavelength of 3.15 centimeters has been measured by radio techniques. A black-body temperature of about 300°C was obtained, on the assumption that this, too, is thermally excited. The uncertainty is near 100°C. Even if the figure of 300° is reduced to 200°C, it is still much higher than the earlier values. This difference may be because such long waves can originate below the visible surface and because part of the energy may be produced electrically rather than thermally.

We never see the solid surface of Venus, only a continuous cloud cover. This is responsible for the high albedo and for the absence of permanent surface markings. Lyot (*8*) has made careful studies of the polarization of the reflected sunlight as a function of the difference between the angle of illumination and the angle of view. He finds that the polarization curve for Venus resembles that of water droplets of diameter 2.5 microns. However, this is not a definitive identification, since polarization depends upon particle size and wavelength as well as upon composition. Measurements at several widely separated wavelengths are clearly needed.

Indeed, the thermal data clearly indicate that the clouds cannot be H_2O, for at such high temperatures the amount of vapor in equilibrium with the clouds could be detected spectrographically. Some have assigned the −38°C radiometric result to the cloud surface. In this case the clouds would be ice particles, and the small amount of vapor in equilibrium with them would go undetected. As we have seen, however, the visible surface must be much warmer than this.

Composition of Clouds on Venus

Speculations about the cloud composition have included the following: (i) dust as the principal component; (ii) the now disproved hypothesis of formaldehyde polymers; and (iii) the recent untested postulation of polymers of carbon suboxide (*4*). This is a very open field for research, in which the definitive solution may well come from a physical chemist who is willing to study the complex reactions of CO_2 under the influence of ultraviolet light (*9*).

Table 1. Salient physical data for selected planets compared with data for Earth.

	Earth	Venus	Mars	Jupiter
Mean distance from sun (Earth = 1)	1.00	0.72	1.52	5.20
Diameter (Earth = 1)	1.00	0.96	0.53	11.0
Mean density (g/cm³)	5.52	5.06	4.12	1.35
Period of revolution about the sun (yr)	1.000	0.6152	1.8808	11.862
Axial rotation period	23^h56^m	?	24^h37^m	9^h50^m–9^h56^m
Inclination of equator to orbital plane	23°27′	?	25°12′	3°07′
Surface gravity (Earth = 1)	1.00	0.86	0.37	2.64
Approximate mean temperature of "visible" surface in sunlight (°C)	+10	+50–+100	−10	−120
Albedo	0.36	0.59	0.15	0.44–0.51

Since we do not see a solid surface it is impossible to determine the axial rotation period by observing the motion of surface features, as we do for Mars. Definite spectrographic evidence exists that the period must be greater than about three weeks. In 1928 Ross (*10*) discovered that ultraviolet photographs of Venus disclosed large light and dark shadings which are variable in form and duration. These ultraviolet markings are poorly understood. Recently Kuiper and Richardson have separately noted periods of preferred orientation of these features. They assume that these features represent convection currents from the sunlit to the dark hemisphere. This would put the markings parallel to the equator and permit calculation of the orientation in space of the pole of rotation. Unfortunately, the two separate determinations of this orientation disagree by a large angle, making the method suspect.

The infrared radiation from Venus' CO_2 is highly variable in amount. Since the atmosphere cannot cool enough from day to day to account for this, it is likely that a second, higher cloud layer forms intermittently to block this radiation, or that the primary cloud surface sometimes is lifted much higher by convection. The relationship between this phenomenon and the ultraviolet markings has never been investigated.

The high temperature of the surface and the scarcity of H_2O and O_2 makes it highly unlikely that life as we know it can exist on Venus.

Fig. 1. Photograph of Venus taken in red light when the planet was between the Earth and the sun, showing a complete ring of light encircling the dark disc of the planet. Venus was then 2¾° from the sun. [Photograph by E. C. Slipher and J. B. Edson of the Lowell Observatory]

Mars

Mars is the nearest planet whose orbit lies outside that of Earth. Thus, when Earth and Mars are closest together we see a fully illuminated planet, in contrast to the quite different situation for Venus. Despite the fact that Mars is smaller than Venus and cannot come as close, the geometry of the orbits of Earth and Mars makes Mars the planet which we can subject to the most detailed telescopic examination.

Perhaps the first evidence that Mars has an atmosphere came from the occasional presence of clouds. In contrast to Venus, Mars' solid surface is usually exposed to visual examination and is only sometimes partly obscured by clouds. These must be supported by an atmosphere. The only constituent which has been positively identified spectrographically is CO_2. This was discovered by Kuiper, in 1948, by means of the 1.6-micron absorption bands; he used an infrared spectrometer with a lead sulfide photoconductive cell as the sensing element. Kuiper (*11*) originally estimated that there is twice as much CO_2 per unit area on Mars as on Earth. However, calculations have been published in which the effect of the interplay of the Martian and telluric lines of the band has been taken into account. These indicate that there is about ten times as much of the gas on Mars as on Earth.

The existence of water vapor in the atmosphere has long been suspected because of the easily seen white polar caps, which wax and wane with the Martian seasons. This assumption was greatly strengthened when Kuiper used the infrared spectrometer to show that the polar caps have the same decrease in reflectivity at 1.5 microns which snow exhibits in the laboratory. Since the caps are H_2O snow, there must be some of the vapor in the atmosphere. Nevertheless, carefully conducted spectrographic tests, in which very high resolution and the Doppler shift method of disentangling the planetary and terrestrial lines were used, have failed to reveal positive evidence for H_2O vapor. The spectrographic records have never been measured for asymmetries of the lines, so we cannot state a firm upper limit for the amount of H_2O, but if all the Martian vapor were condensed to liquid, it probably would not occupy a layer more than a small fraction of a millimeter thick. The Martian atmosphere is surely extremely arid. No bodies of liquid H_2O could last long in such a dry atmosphere, so there are no lakes, rivers, or oceans on Mars.

Argon is very probably present. All terrestrial argon was produced by decay of radioactive potassium-40. If we assume that the crust of Mars has the same proportion of K^{40} as that of Earth, there should be about 13 grams of argon per square centimeter of the planet's surface.

Various methods, mostly optical, have been used to determine the total amount of Martian atmosphere (*12*). The measurements are difficult to make, but it is probable that the surface pressure is 50 to 100 millibars. This is to be contrasted with normal terrestrial sea-level pressure of slightly more than 1000 millibars. Of course, gravity on Mars is only 0.37 of ours, so the mass of atmosphere per unit area is evidently between one-eighth and one-third of our own. The gases already discussed do not amount to this much, and nitrogen is thought to constitute the bulk of the atmosphere. The absorptions of nitrogen are all in the portion of the ultraviolet to which our atmosphere is opaque, so no direct spectrographic evidence is available to support this idea. Such data might be obtained by means of a rocket.

Temperature Distributions on Mars

Temperature distributions over the face of the planet have been determined radiometrically (*13*). When the sun is directly overhead, the surface temperature may rise as high as +30°C. The temperature decreases towards the poles at a rapid rate in the winter hemisphere and less rapidly in the summer hemisphere, as would be expected. The small summer polar cap has a temperature somewhat below 0°C, and the most poleward latitude measurable in the winter hemisphere, one of about −60°C. We do not know the nighttime minimum temperatures, but it has been estimated that even at the equator they may fall as low as −100°C. Certainly, the diurnal range of temperature exceeds anything we experience on Earth. This is primarily due to the great dryness of the Martian atmosphere, which cannot provide a strong "greenhouse" effect.

The radiometric data apply to areas of the planet that are small enough to permit the temperatures to be plotted on a map and analyzed in very much the same way that terrestrial meteorological temperatures are plotted and analyzed. The Martian temperature maps are qualitatively similar to terrestrial ones. Since there is a well-known link between temperature and pressure gradients and, on rotating planets, between pressure gradients and wind, there is reason to believe that Mars has a general atmospheric circulation similar to that of the Earth. Therefore, the detailed study of this circulation is a matter of potentially great interest to meteorologists. As we shall see, however, it is not easy to gather detailed circulation data for Mars.

Martian Clouds

Martian clouds may be divided into two main classes: the occasional and ephemeral ones, which can be detected visually or photographed in yellow or red light and the persistent, widespread clouds observable on photographs in blue light, called "blue haze." Most of the visible clouds are observed near the morning and afternoon limbs and are presumably due to low-level condensation of the meager water vapor at the low temperature of those places. Thin ice fogs are probably common during the very cold Martian night. White and yellowish clouds are sometimes seen closer to the center of the planetary disc. These may be due to high-level convective condensation of water vapor (white clouds) and dust storms (yellowish clouds). The only way the atmospheric circulation may be studied is by observing the drift of these visible clouds. Unfortunately, the clouds move too slowly to permit reliable measurement of the motion in a few hours, and they are so ephemeral that the same cloud is rarely observable on successive nights. A preliminary attempt (*14*) to study the existing data suggested great similarity to terrestrial circulation, even as to details. However, this result needs to be extended and verified. I am in the process of assembling and studying the Martian cloud data gathered by a global chain of observers during the close approach of Mars in 1956.

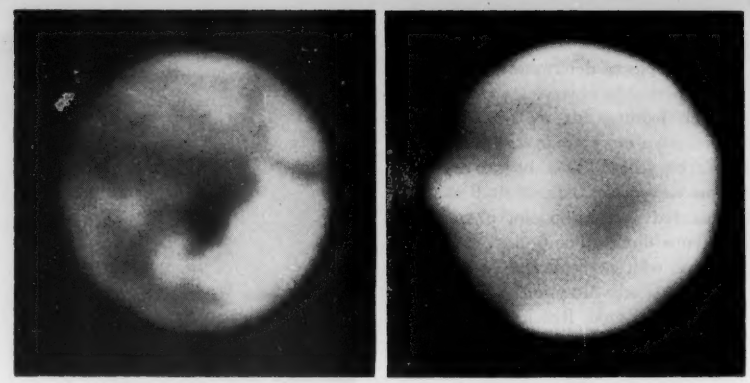

Fig. 2. Two photographs of Mars taken in red and blue light, respectively, on the same night (11 June 1954). The dark Syrtis Major and other well-known Martian surface features show clearly in the red-light photograph (left) but are obscured in the blue-light photograph (right). [Photographs by E. C. Slipher and A. P. Fitzgerald of the Lowell Observatory–National Geographic Society Expedition to the Lamont-Hussey Observatory, Bloemfontein, Union of South Africa]

The blue haze is of great scientific interest. Figure 2 shows a photograph of the planet, taken in red light, in which surface features are easily seen, and a photograph of the same face of the planet, taken in blue light, in which the haze completely obscures all surface features. This haze is relatively thin; it suffices to obscure the dark Martian markings, which do not have high contrast against the lighter areas, but often does not suffice to conceal the more contrasty polar caps. On occasion the haze clears away and permits the surface detail to show through. Such behavior means that this is an atmospheric phenomenon. There is reason to believe (*15*) that the blue haze consists of a layer of H_2O ice crystals a few kilometers thick at an elevation of 30 to 35 kilometers above the surface, near the Martian tropopause. When warming occurs at these levels, as it will sporadically, the haze evaporates partially and the surface can be photographed in blue light. From polarization data it appears that the ice particles have a mean radius of about 0.2 micron.

In the absence of O_2 and of appreciable amounts of H_2O, animal life similar to that on Earth cannot exist. However, the existence of bacterial and elementary plant life is not an impossibility (*16*). The dark areas of Mars, which increase in size and contrast during summer and weaken in winter, have long been thought to be caused by a form of vegetation. Sinton (*17*) has found evidence for absorption due to the fundamental vibration of the C—H bond at 3.45 microns in the reflection spectrum of Mars. Such a demonstration of the existence of organic molecules at the surface is of great importance and should be repeated and verified.

Jupiter

Jupiter, like Venus, is completely covered with clouds, but the cloud surface is not essentially featureless, as it is on Venus; it exhibits a large array of dark belts and light zones, spots of various sizes and colors, and wisps of cloud material. The telescopic appearance of Jupiter is shown in Fig. 3. Most of these cloud features are persistent. Many of the spots can be followed for months, with the result that accurate rotation periods can be determined. These periods indicate that the visible features are not all rotating at the same rate. This, together with changes in appearance from time to time, indicates that

we are dealing with a cloud surface and, therefore, with a planetary atmosphere.

It has been known since the 1860's that the spectrum of Jupiter exhibits band absorption in the red. With virtually every extension of the sensitivity of photographic emulsions into the infrared, more such absorptions were discovered. For a long time the gases causing these bands remained unidentified, until, in 1932, Rupert Wildt, then a physical chemist but now an astrophysicist, pointed out that CH_4 and NH_3 had known absorptions at some of these same wavelengths. Experimental spectra of methane and ammonia in the laboratory were soon obtained which verified this suggestion and established that these gases are constituents of the Jovian atmosphere. We now know that above the cloud surface there is an amount of methane equivalent to 150 meters of the gas at a pressure of 760 millimeters of mercury and a temperature of 0°C and an amount of ammonia equivalent to 7 meters under the same conditions.

We have indirect evidence that the atmosphere must consist largely of H_2 and He, with CH_4 and NH_3 as minor constituents. The argument is this: The oblateness of a planet depends not only upon its rotation rate and surface gravity but upon the distribution of density from the center outward. The oblateness, gravity, and rotation rate for Jupiter indicate a high degree of concentration of mass near the planet's center. Thus, the outer layers must have a density less than the over-all mean density, which is only 1.35 grams per cubic centimeter. The only way in which a sufficiently low density can be obtained for the outermost layer is for the atmosphere to be quite deep (to extend well below the visible upper surface of the clouds) and to be composed predominantly of the lightest gases known—namely, hydrogen and helium. Similar arguments can be made for Jupiter's fellow planets, Saturn, Uranus, and Neptune.

Under normal conditions, H_2 and He do not absorb light in the portions of the spectrum to which our atmosphere is transparent, because these molecules possess no dipole moment. Thus, a direct spectrographic verification of the above argument appears to be impossible. However, H_2 under high pressure and low temperature does exhibit a weak quadrupole spectrum in the photographic infrared. Herzberg (*2*) has observed these absorptions in the laboratory and has shown that a feature observed in the spectrum of Uranus and Neptune by Kuiper at 8270 angstroms is probably due to this absorption of H_2. Since Herzberg found this line in the laboratory at 8258 angstroms, there is a small discrepancy which requires explanation.

The quadrupole spectrum of H_2 is not observed on Jupiter because the amount of gas above the clouds is too small and the temperature is too high to permit a sufficiently sharp line to be developed. Nevertheless, if Uranus and Neptune could retain hydrogen, the more massive Jupiter certainly could do so.

Temperatures on Jupiter

The radiometric technique for determining planetary temperatures indicates about −145°C for Jupiter. However, this is too low, because NH_3 plays the same role on Jupiter that CO_2 does on Venus. That is, the infrared energy measured by the radiometer comes partly from cold ammonia gas high in the atmosphere and partly from the warmer cloud surface below. Methane does not interfere with infrared radiation, since such symmetrical molecules have no infrared spectrum. The temperature is probably sufficiently low, even at the cloud surface, to cause condensation of ammonia into the solid form. It is very likely that the clouds are predominantly NH_3 crystals—that is, "ammonia cirrus." Indeed, this assumption offers the most delicate way of estimating the temperature of the clouds. Since we know the total amount of ammonia in a vertical column, we can estimate the ammonia vapor pressure at the visible surface. But when condensation occurs, this vapor pressure is a known function of the temperature alone. The only assumption which must be made is that the ammonia is well-mixed vertically and not concentrated at the bottom of the vertical column. This assumption cannot disturb the results very much because, fortunately, a large change in NH_3 vapor pressure implies a small change in temperature at condensation. Nevertheless, this means that the cloud temperature of −120°C, calculated in this way, is a lower limit. The actual temperature may be a few degrees higher.

In contrast, methane cannot condense at so high a temperature at any conceivable pressure. Thus, in principle, it is possible to determine relative elevations of the visible cloud surface by measuring the intensity of absorption by methane at various points on the planet. Similar measurements for ammonia should give the temperature distribution over the planet. Such measurements and calculations (*18*) indicate that the cloud surface is lowest at the equator at local noon and is about 10 kilometers higher near latitudes 60°N and 60°S, and 10 kilometers higher at longitudes 60°E and 60°W of the central point along the equator. The temperature was found to be highest at the equator at local noon and about 6°C cooler at latitudes 60°N and 60°S. Along the equator the temperature was also found to decrease towards the east and west limbs. At 60° of longitude away from local noon, towards the evening limb, the temperature was 4°C cooler than at local noon. The corresponding point on the equator towards the morning limb was 8° to 9°C cooler than at local noon. This is

Fig. 3. Blue-light photograph of Jupiter in 1928 showing the banded structure, a variety of cloud features, and the Great Red Spot in the upper central part of the disc. The dark cloud feature to the left of the Great Red Spot moved relative to the dark clouds just below the spot with a speed of 8000 miles per day. [Photograph by E. C. Slipher, Lowell Observatory]

the kind of asymmetry in the diurnal temperature curve which one would expect if solar heating plays a major role in the planetary heat budget. There is considerable variation of opinion about the importance of heat that emerges from a possibly warm interior, but these ammonia-temperature data suggest that solar heating is dominant.

Cloud Motions on Jupiter

Because of the profusion of persistent cloud features, it is possible to gather extensive data concerning cloud motion. These data have been gathered and published for many years by the Jupiter section of the British Astronomical Association. Despite the large amount of information available, we do not understand the Jovian general circulation at all well because the atmosphere is so complex. The contrast to Mars is quite frustrating, for there the atmosphere is simple enough so that we could probably explain the circulation reasonably well if we had an adequate description. However, Martian cloud-drift data are so rare that we have difficulty in describing the features to be explained.

The outstanding circulation features of Jupiter are these: (i) The flow is primarily zonal, with rare northward and southward motions, and (ii) the equatorial zone (about 8°N to 8°S) rotates with a period of approximately 9 hours and 50 minutes, while the rest of the atmosphere rotates with a mean period of 9 hours and 55 minutes. This difference corresponds to a difference in zonal speed of about 200 miles per hour. A similar more rapid rotation near the equator is also observed on the sun and on Saturn. It may be a characteristic of very deep atmospheres. Although attempts have been made to explain theoretically such so-called "equatorial accelerations," these explanations fall short of being convincing. We have virtually no understanding of this phenomenon.

Poleward of latitudes 8°N and 8°S there are relatively small fluctuations in rotation rate which are associated with the alternation of light and dark bands. The wind shears observed indicate that the light bands are anticyclonic high-pressure belts with upward motion and that the dark bands are cyclonic low-pressure belts with descending motion (*19*). The ascent produces adiabatic cooling and increased condensation of ammonia; this explains the high reflectivity of the light bands. The descent produces adiabatic warming with evaporation of the ammonia clouds; this explains the low reflectivity of the dark bands.

Jupiter's "Great Red Spot"

An outstanding puzzle is the "Great Red Spot," a visible oval about 25,000 miles long and 8000 miles wide found near latitude 22°S. This object has been present for at least the last 80 years and probably for more than 100 years. It is characteristically brick-red, although it is sometimes white. The shape and dimensions fluctuate somewhat but give the impression of frequently returning to a fixed basic state. These facts strongly suggest that the Great Red Spot is a solid mountain-like mass protruding through the cloud layer. The changes in shape and size then would be due to small variations in the level of the clouds, and the change from red to white can be thought of as arising from deposition of ammonia snow on the mountain. Indeed, the manner in which cloud matter flows around the Great Red Spot strongly resembles the flow of the terrestrial atmosphere around the Tibetan plateau, which is in shape and relative size an analog of the Great Red Spot. A difficulty arises from the fact that this object does not rotate with a constant period. Therefore, it cannot be fixed to the solid part of the planet below the clouds. It has been suggested that it is a floating island with its base well below the cloud surface. This would, indeed, explain all the observations, but it is very difficult to imagine what solid substance can have a sufficiently low density to float in an atmosphere. The metallic phase of solid hydrogen has been suggested, but it is unlikely that this substance could persist at the low pressures in and near the visible cloud surface. The problem remains unsolved.

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Protein Hydration and Behavior

Many aspects of protein behavior can be interpreted in terms of frozen water of hydration.

Irving M. Klotz

It is the purpose of this article to reexamine some of the distinctive properties of protein molecules in the light of certain ideas which have appeared sporadically in the literature and which, if applied on a broad scale, provide a more unified and plausible interpretation of the singular behavior of these substances. This reexamination was stimulated by certain problems which we encountered in studies of what is perhaps the simplest reaction of protein molecules, combination with a proton in aqueous solution:

$$P + H^+ = PH^+$$

Consequently, a description will be given also of some of the unusual features of this reaction. However, we shall not discuss this reaction per se but rather analyze it in the context of what it might reveal about the structure and behavior of protein molecules.

Some Problems in Protein Behavior

As a prefatory background, therefore, let us consider some of the chemical and physical properties which mark proteins as unique. That is, let us examine some reactions or aspects of physicochemical behavior of proteins for which there are counterparts in simple nonprotein systems but in which the introduction of a protein environment produces some marked differences. The particular examples which one might choose to illustrate the unique character of proteins are largely a matter of taste. A reasonable selection from among many alternatives might be the following four.

Masked groups. From an analysis of the amino acid composition of proteins, one knows or expects certain functional groups to be present—for example, phenolic or mercaptan groups. Nevertheless, these may not be detectable in the native protein although they do become evident in the denatured material (*1*). Mercaptan groups have been the most extensively examined in this connection. As a typical example, an amperometric silver titration of mercaptan in hemerythrin is shown in Fig. 1. When the protein is dissolved in aqueous salt solution (curve A), added silver ion produces an immediate increase in diffusion current, indicating that the metal ion is not bound to protein mercaptan. On the other hand, in the presence of urea, even an immediate titration (curve *B*) shows a much slower rise of free silver than in water alone, and a titration after 1 hour in urea (curve *C*) shows no free silver until the total metal exceeds a value (about 0.5 cm³) corresponding to the mercaptan content of this protein. Thus, the mercaptan groups are evidently present in the protein, but in the native state they are inaccessible to a particular reagent—silver in the experiments of Fig. 1. The molecular basis of this masking has been the subject of much speculation, suggestions having ranged from that of a chemically modified state (thiazolines) (*2*) to that of steric blocking by hydrogen-bonding or by side-chain groups (*2*, *3*).

Denaturation. An examination of the meaning of this term in general would involve a prolonged discussion which would distract from the principal objective of this article. Let us consider, therefore, merely one typical example of denaturation, that of the enzyme aldolase. The activity of this enzyme (*4*) in aqueous solutions of increasing urea concentrations is fairly constant up to 1*M* urea and then falls rapidly, reaching zero at about 3.5*M* (Fig. 2). In this particular example, activity is regained if the enzyme in urea solution is diluted to reduce the urea concentration markedly—that is, the denaturation can be "reversed." In molecular terms, denaturation is usually ascribed to a disorientation of the structure of the protein molecule (see Fig. 3), renaturation to a reorganization of the structure to its original form.

Volume changes. Proteins undergo striking volume changes when they are denatured chemically or when they are denatured and hydrolyzed enzymatically. The latter phenomena have been studied extensively in the Carlsberg laboratories (*5*), and some of the observations made there are summarzied in Fig. 4. For orientation purposes, a hatched region is shown for the small volume change, −15 to −20 cm³/mole, normally found for the hydrolysis of simple peptides. In contrast, the hydrolysis of β-lactoglobulin by trypsin at, for example, 0°C is accompanied by a marked decrease in volume, particularly for the splitting of the first few bonds. It is evident that a pronounced collapse in effective volume of β-lactoglobulin occurs in the early stages of tryptic hydrolysis, the contraction being more than five times as great as that found with simple peptides.

Cooperative effects. There are many instances in protein behavior where combination of the macromolecule with one small ion or molecule makes it much easier for succeeding molecules to become attached. Perhaps the best examples of such cooperative effects are the oxygen-carrying proteins, notably hemoglobin. The familiar S-shaped curve for oxygen uptake (Fig. 5) (*6*) indicates clearly that oxygen is bound more readily after some has already been taken up by the hemoglobin molecule. These effects can be expressed quantitatively if the observed equilibrium constants (k_i) for the uptake of oxygen by each of the four sites of the protein molecule, are compared with the values to be expected if each site acted completely independently (Fig. 6) (*7*). With independent sites, $k_1 > k_2 > k_3 > k_4$, simply for statistical reasons (*8*). The observed values of k_i for hemoglobin are much higher than the statistical values (Fig. 6). Such behavior is not a property of the heme groups as such, however, for cooperative effects are also present in the heme-lacking oxygen pigments hemocyanin and hemerythrin (*9*).

Uptake of Protons by Protein Molecules

With these unusual properties of protein molecules in mind, let us turn to an examination of some aspects of their

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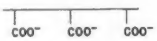
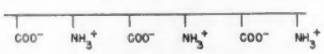
titration behavior. As an introduction let us consider the behavior of a very simple system, a mole of formate ion, $HCOO^-$, in solution, as H^+ ions are added in progressively increasing amount. As Fig. 7*A* illustrates, below *p*H 6, the amount of H^+ which combines with formate, to form HCOOH, increases in the form of a typical (reversed) S-shaped titration curve as the *p*H drops. A plateau of 1 mole of H^+ per mole of total formate originally present is reached at about *p*H 2. As is well known, the *p*H of the midpoint of this titration curve equals the *pK* of formic acid. Essentially the same curve would be obtained if 100 moles of formate were originally present, and if the ordinate were moles of H^+ combined with 100 moles of formate. Likewise, Fig. 7*A* would represent correctly the acid titration of 100 moles of carboxyl groups joined in one large polymer molecule I



(I)

if these groups were spaced at sufficiently large intervals so that they had no electrostatic influence on each other.

Let us examine now the actual behavior found in the titration of carboxyl groups in protein molecules. Illustrated in Fig. 7*B* are the ideal curve for the behavior of 100 identical groups without electrostatic interactions and the actual curve observed in the acid titration of the approximately 100 carboxyl groups in serum albumin (*10*). With albumin the uptake of H^+ is spread out over a wider *p*H range. A possible reason for this flattening is readily evident, however, as soon as one recognizes that a protein contains charged groups in addition to its carboxyls, and that the distance between substituents is limited by the over-all size of the molecule. Schematically we may represent the situation by II.



(II)

From this diagram it becomes apparent that when, for example, one proton has combined with one —COO^- group, the protein will carry a net positive charge due to the cationic groups, and this charge may make it more difficult for succeeding protons to combine with the protein. In essence, then, we shall need a lower *p*H—that is, a stronger proton pressure—to force a proton onto a —COO^- group; therefore, the titration curve is stretched toward lower *p*H's.

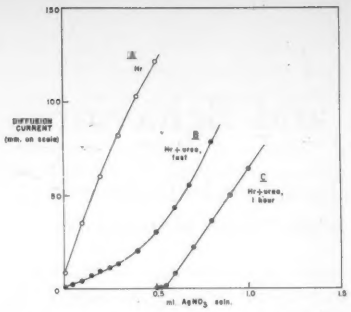


Fig. 1. Amperometric titrations of hemerythrin with silver ion: *A*, hemerythrin in aqueous solution; *B*, hemerythrin in 8*M* urea solution upon immediate titration; *C*, hemerythrin in 8*M* urea, silver ion added and solution allowed to stand for 1 hour before further titration. [I. M. Klotz, T. A. Klotz, H. A. Fiess (*50*)]

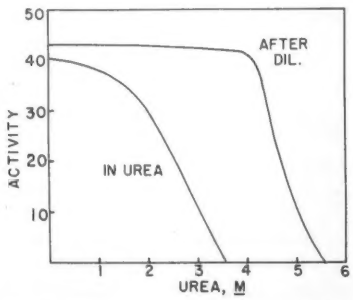


Fig. 2. (Lower curve) Activity of aldolase as a function of concentration of urea in solution. (Upper curve) Activity of aldolase after solution of enzyme in urea of given concentration is diluted with water to a urea concentration of 0.08*M*. [A. D. Swenson and P. D. Boyer (*4*)]

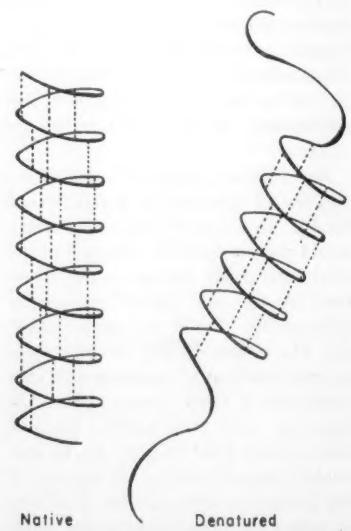


Fig. 3. A model for protein denaturation.

These electrostatic considerations can be formulated in quantitative terms and have been so expressed (*11*). The titration curves of some proteins can then be accounted for quantitatively reasonably well. More often, however, there are large deviations from predictions based on electrostatic theory. Discrepancies can still be explained by various additional assumptions for specific cases (*10*). Alternatively, one could also account for an observed acid titration curve by assuming, quite reasonably, that each or most of the carboxyl groups are not really identical, for their environments, in terms of which amino acid residues are their neighbors, are very likely quite different. Consequently, the observed behavior of carboxyl groups in a protein may actually be the composite result of, for example, nearly one hundred different carboxyl groups with different *pK*'s, the distribution of *pK*'s being such as to produce the observed flattened titration curve.

It seemed to us that a promising approach to the assessment of the contribution of electrostatic and various specific factors to the behavior of protein molecules might be a study of the proton equilibria of a *single* group in a protein. If electrostatic effects are influential, they should still modify the ionic behavior of even a single residue, for as the *p*H of the solution is lowered, the net positive charge of the protein molecules will be increased. Consequently, those molecules still containing the singled-out residue in its basic state should not take up hydrogen ions as easily; the titration curve should be stretched out and should look like the actual curve of Fig. 7*B*, even though only a single residue is titrated. On the other hand, if the residue is not subject to electrostatic influences from other side-chains, the titration curve should be in a form approximating the ideal curve of Fig. 7*B*.

From these considerations it follows that carboxyl groups of proteins are not suited for our purposes, since so many of these are normally present in a protein. There are usually fewer imidazole or tyrosine groups, but even these are commonly present in appreciable number, and their proton equilibria overlap those of amino groups so that a sharp separation cannot be made by electrometric methods. The proton-donor group usually present in smallest number in proteins is the sulfhydryl. Here again, however, a direct study of its dissociation by electrometric methods is not feasible, since the equilibria of amino and tyrosine groups would obscure the contribu-

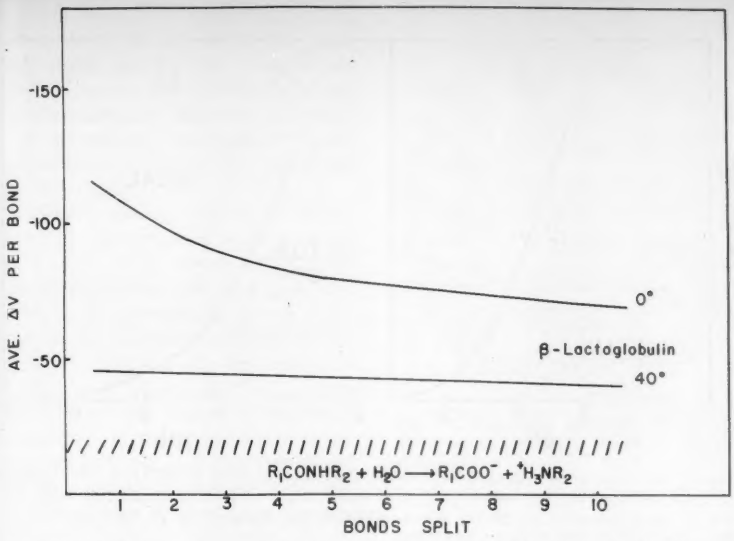
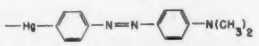


Fig. 4. Volume changes accompanying hydrolysis. [K. Linderstrom-Lang (*5*)]

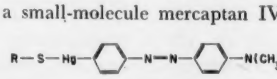
tion of the thiol. An alternative approach, which could still take advantage of the small number of —SH groups, would be to introduce a molecule which reacts specifically with the mercaptan side chain, and which contains a substituent whose proton uptake, or release, is accompanied by a marked change in visible spectrum (*12*). In this way one could follow the ionic equilibrium of the marked residue without any obscurant effects from the many simultaneous proton equilibria of other side chains, since the latter are all uncolored. An example of a suitable labeling molecule is the azomercurial III



(III)

which combines specifically with the mercaptan groups of proteins and undergoes marked alterations in absorption of light over a characteristic *p*H range.

The *pK* of the $-N(CH_3)_2$ group in III is generally unaffected by changes in substituents at the opposite end of the azobenzene nucleus (*13*). Nevertheless, it seemed prudent to examine the proton equilibrium of III when it is attached to a small-molecule mercaptan IV



(IV)

so that any effect of the sulfur-mercury linkage to be use in attaching this molecule to the protein could be evaluated in a non-protein environment. As anticipated, the *pK* of the cationic form of IV, 3.4, was not significantly different from the *pK*'s of other para-substituted azobenzenes, about 3.4.

When the azomercurial (III) is attached to a protein, however, some surprising behavior is observed (Fig. 8). The *shape* of the titration curve of the dye in the protein, from *p*H 3.5 down to almost 0, is not greatly different from that of the dye attached to a small molecule (for example, cysteine) in aqueous solution. In the cysteine complex a rise in absorption becomes detectable with increasing acidity immediately below *p*H 5. When the dye is attached to serum albumin, with an isoelectric point near *p*H 5, one would expect, if electrostatic effects were important, that the optical density would also rise as soon as the *p*H passes below 5 and would continue to rise with decreasing *p*H, but at a somewhat slower rate due to the increasingly positive charge on the proton. Actually, the rise in absorption due to uptake of H^+ by the dye attached to protein really begins only as the *p*H drops below 3, and then goes up sharply. The titration curve of $-N(CH_3)_2$ attached to the protein is not stretched out over a wider *p*H range than in the cysteine complex.

It would seem, therefore, that the ionic behavior of the $-N(CH_3)_2$ group is not affected by the presence of other charged groups in the protein molecule. Confirmation of this conclusion is also obtained from another titration, in the presence of 30 dodecyl sulfate anions per protein molecule. Since these negatively charged ions are all bound to the positively charged protein, one would expect an appreciable decrease in the electrostatic effect of groups on the protein molecule; no such change is observed (*12*).

In view of the absence of electrostatic effects from neighboring side chains on the ionization behavior of the $-N(CH_3)_2$ group on the protein, the relative position of the titration curve for dye-albumin in Fig. 8 is most peculiar. The mid-point of the titration, 1.7, which we might call the apparent *pK*, is very low compared to the value of 3.4 observed for the dye attached to a small-molecule mercaptan. Such behavior, furthermore, is not limited to this single protein. Experiments have been carried out also with ovalbumin and β-lactoglobulin. Although there are individual differences between these proteins, they both show essential similarities to serum albumin in that their *pK*'s are quite low —about 1.2 and 2.3, respectively.

Thus, with all three proteins, it is harder for a hydrogen ion to get on to the $-N(CH_3)_2$ substituent when the latter is attached to the macromolecule than when it is in simple aqueous solution attached to cysteine. Such behavior is reminiscent of the difficulty Ag^+ ions have in combining with mercaptan groups on native proteins, as was described earlier. We might say, therefore, that the $-N(CH_3)_2$ group attached to the protein behaves as if it were "masked." Evidently a "masked" group can be introduced synthetically as well as in natural biosynthesis.

Because of the analogy with the characteristics of naturally occurring masked groups, we might be curious to know whether unmasking of the $-N(CH_3)_2$ can be produced by denaturing agents. One of the most common denaturants is urea. Strikingly enough, the *pK* of the azomercurial $-N(CH_3)_2$ group attached to proteins but in concentrated urea solu-

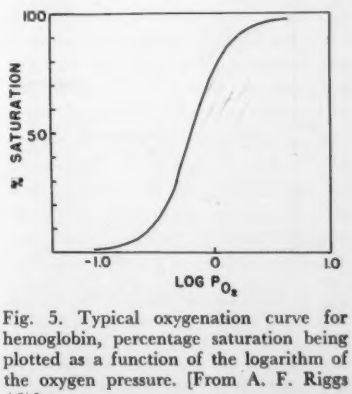


Fig. 5. Typical oxygenation curve for hemoglobin, percentage saturation being plotted as a function of the logarithm of the oxygen pressure. [From A. F. Riggs (*6*)]

tions is 3.3, experimentally indistinguishable from the pK of this group when the azomercurial is attached to cysteine. Furthermore, in urea all three proteins—serum albumin, ovalbumin, and β-lactoglobulin—show the same pK_a for the azomercurial, even though they are readily differentiable in the native state.

An Interpretation of the Behavior of Proteins in Solution

We are thus faced with the question of what is the molecular basis of this masking. Since it also occurs with the artificial group which we have introduced into proteins, an explanation based on steric interferences from side chains of conveniently adjacent residues in all three proteins seems unlikely, for it is difficult to see why the protein configuration should be just so arranged in every case as to be able to mask the *artificially introduced* side chain. Furthermore, the degree of "maskedness" of the original —SH groups in serum albumin, ovalbumin, and β-lactoglobulin is markedly different. For example, in serum albumin, there seems to be little or no interference with the sulfhydryl group, as judged from titrations with Ag^+ or an organic mercurial, whereas in β-lactoglobulin there is much interference. Nevertheless, in both proteins, the artificially introduced group is masked—in fact, more masked in serum albumin than in β-lactoglobulin, as judged from the shifts in pK_a. Such behavior is difficult to understand in terms of steric interference because of protein configuration. An alternative approach based on the following considerations seems more fruitful.

A H^+ ion can clearly reach the $-N(CH_3)_2$ group of the protein, although, as judged from the lower pK_a, the environment is not as hospitable to it. It would seem, therefore, that the azomercurial on the protein is in an aqueous environment but not a normal one. One is led to ask, therefore, whether the water in the vicinity of the protein is not different in structure from that in the bulk of the solution.

It has long been recognized, of course, that in aqueous solution macromolecules as well as small molecules are hydrated. Nevertheless, the first strong emphasis on the importance of "icebergs" around solute molecules in water was probably that made in the papers of Frank and Evans (*14*; see also *15–18*). Since that time this concept of "frozen" hydration shells has been utilized in interpretations of various phenomena involving macromolecules. For example, in connection with studies of entropy changes in the formation of protein complexes (*19*) we have suggested that disorganization of "frozen" water of hydration plays a dominant role. Reasoning from analogous thermodynamic grounds, Eisenberg and Schwert (*20*) have interpreted their observations on the reversible denaturation of chymotrypsinogen in terms of the partial dehydration (*21*) of icelike water on the protein molecule. Similarly, Jacobson has shown from nuclear magnetic resonance (*22*) and other studies (*23*) that nucleic acids in solution are surrounded by a hydration shell of lattice-ordered water. An analogous concept has been used by Szent-Gyorgyi (*24*) in the interpretation of fluorescence experiments and their relationship to problems of energy transfer in biological systems.

An examination of the titration behavior, and of some of the other unique characteristics of proteins described earlier in this article, from the viewpoint of the "iceberg" nature of the hydration water reveals a pattern for the explanation of many seemingly unrelated phenomena. It is necessary first to keep in mind the various ways in which a solute can affect the structure of water in its neighborhood. An ion imposes a structure on the first hydration shell in which all the water molecules are oriented in a centrosymmetric fashion. Somewhat farther from the ion, the electric field is usually not strong enough to effect the same orientation but generally is sufficient to disrupt any lattice structure organized by cooperative effects in the water itself (*16*). With a nonpolar solute, however, any disorientation effect due to the electric field disappears, and a lattice-ordering effect predominates, as seems evident from many physicochemical properties of nonpolar solutes in water (*14–18*). Nonpolar side chains in proteins might be expected, likewise, to induce a crystalline, cagelike, arrangement of hydration water, with the added possibilities of long-range cooperative

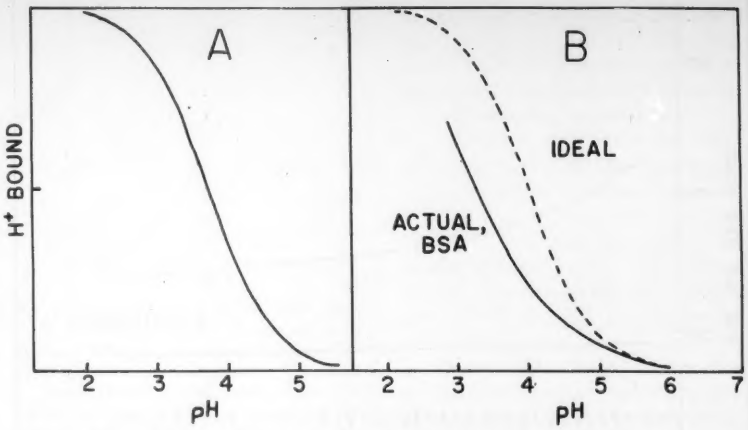


Fig. 7. (A) Uptake of hydrogen ions by a carboxylate ion such as $HCOO^-$; (B) uptake of hydrogen ions by 100 carboxylate ions under ideal conditions, compared with the actual curve observed for bovine serum albumin. [C. Tanford, S. A. Swanson, W. S. Shore (*10*)]

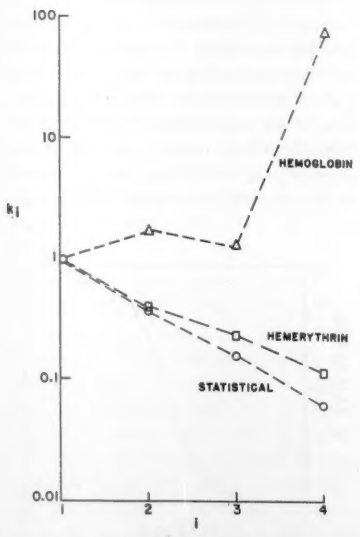


Fig. 6. Equilibrium constants for the uptake of an oxygen molecule at each of the four sites of hemoglobin (*7*) and of hemerythrin (*9*) compared with the relative values to be expected purely from probability considerations.

effects due to the presence of many such side chains bound to the frame of the protein molecule. It is in terms of the icelike nature of this hydration water (*14–18*) that we can account for much of the puzzling behavior of proteins described above.

Titration behavior. Within the framework of this concept we would view the drop in pK_a of the dimethylamino group in the environment of the protein as a consequence of the rigid iceberg structure in the neighborhood of the macromolecule (Fig. 9). If the proton attached itself to the $-N(CH_3)_2$, some disruption of the stable cagelike hydration lattice of the protein would be required, and this rearrangement would be more difficult to carry out in the protein than in an ordinary water environment.

With serum albumin (in contrast to ovalbumin), a detailed examination (*12*) of the shape of the titration curve of the bound $-N(CH_3)_2$ group indicates that this cagelike freezing becomes particularly extensive below *p*H 4.2. Evidently the extent and rigidity of the hydration envelope increases substantially and may contribute to changes in hydrodynamic properties and optical characteristics described in the literature (*25*).

The effect of urea, bringing the pK_a back up to 3.3, is then easy to understand. In essence, in the presence of urea, the dye attached to protein behaves in its ionization just like the dye in water, free from protein. An appropriate inference might be, therefore, that urea, because of its strong hydrogen-bonding characteristics, breaks down the "frozen" structure of the water envelope of the protein and transforms it into one more nearly like that of the bulk aqueous environment.

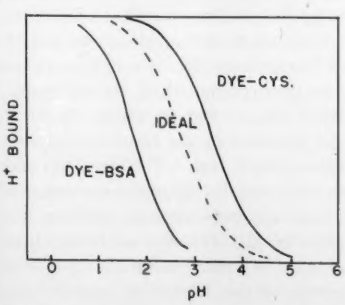


Fig. 8. Titration curves for III when attached to bovine serum albumin or to cysteine, as compared to its behavior in ideal circumstances. The dye-cysteine curve could be superimposed on the ideal. The dye-protein curve almost fits the ideal, but is probably slightly steeper, certainly not flatter.

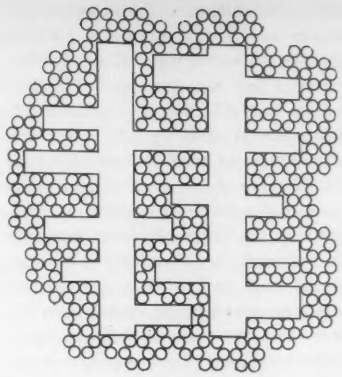


Fig. 9. Schematic diagram of icelike character of hydration sheath of protein molecule.

Volume measurements. Let us examine first in this connection the molal volumes of proteins in aqueous solution. McMeekin and Marshall (*26*) have shown that the value of this volume computed from the sum of the specific volumes of the constituent amino acid residues agrees very well with observed numbers. As Edsall (*27*) and Waugh (*28*) have pointed out, such agreement is very surprising since no correction is made for the electrostriction effects of charged residues. For human serum albumin, for example, electrostriction ought to reduce the volume by about 1800 cm³ per mole of protein molecules; for ovalbumin, by 730 cm³ and for β-lactoglobulin, by 830 cm³. Since these decreases in volume are not observed, it seems reasonable to infer that some other phenomenon produces a compensating increase in volume when the amino acid residues are joined in a protein. We would suggest that this increase in volume comes from the fixation of the hydration water of the protein into an icelike lattice (Fig. 9). There is good reason to believe that the hydration ice around nonpolar solutes is similar in density to ordinary ice (*15, 17, 18*). By analogy with the freezing of ordinary water one would expect, therefore, an increase in volume upon formation of the hydration iceberg of the protein. Some interesting calculations can be made in this direction. The freezing of water is associated with a volume increase of about 2 cm³ per mole. If one attributes the 1800 cm³ volume increase of serum albumin, which compensates for electrostriction decreases, to the freezing of water, one can compute the number of water molecules fixed and, thereby, the percentage hydration of the protein. Similar computations can be made for ovalbumin or β-lactoglobulin. The results give hydrations of close to 20 percent by weight, in very good agreement with the best measured values (*29*).

The volume changes accompanying proteolysis (*5*) (Fig. 4) also follow as a natural consequence of the iceberg picture. In particular, the large values of ΔV at the onset of proteolysis would seem to be a reflection of extensive disarrangements in the water lattice at the surface of the substrate protein molecule at the beginning of the enzymatic attack. Thus, the common observation that proteolytic enzymes seem to denature the substrate protein before hydrolyzing it would be a natural expectation. Likewise, one could readily interpret the general experience that these enzymes act more readily on previously denatured substrates.

It is also of interest to note in Fig. 4 that the volume decrements during hydrolysis at 0°C are substantially larger than those observed at 40°C. Such behavior would be eminently reasonable from the iceberg viewpoint, for one would expect more extensive freezing at the lower temperature.

Some quantitative estimates of hydration can also be made from the observed volume changes during hydrolysis. For complete hydrolysis of β-lactoglobulin, Linderstrom-Lang (*5*) has estimated a ΔV of 700 cm³ (at 40°C), after correction for electrostriction effects. This volume change corresponds to about 17-percent hydration, again in good agreement with generally accepted values.

Masking and denaturation. Masking of naturally occurring functional groups of proteins, as of the artificially introduced $-N(CH_3)_2$ group, can be attributed to a "freezing" of the water structure in the neighborhood of that site (Fig. 9). Lack of reactivity of such hindered groups (for example, mercaptan) is usually only relative and dependent on the reagent. The effectiveness of a reagent in combining with a masked group might very well be related to its ability to dissolve in, or to disorient, the lattice structure of the iceberg covering the group. Similarly, the effects of denaturing agents, such as urea, in "unmasking" blocked functional groups may be due to the rearrangements which these reagents produce in the structure of the water envelope characteristic of the native protein.

In terms of the melting of the water of the "metastructure" of the protein, it

is to be expected that denaturation would be accompanied by an over-all volume contraction. It is striking that such indeed is the case, not only for the enzymatic proteolyses described above but also for denaturation by urea, or alkali (*5, 28, 30*). Volume contractions of about 250 cm^3 per mole of protein have been observed in alkaline denaturation, and as high as 300 cm^3 in urea denaturation.

The larger volume changes accompanying enzymatic hydrolysis are probably due to a much greater disruption of the macromolecular structure in the hydrolytic process.

The reversibility of some denaturation processes—for example, after removal of urea or after cooling of a heated solution—is also more readily understandable in terms of the iceberg picture. If the effect of urea or heat is to disrupt the hydration lattice but not to disturb the polypeptide configuration, then it is easy to understand that the removal of urea or heat should lead to a reformation of the specific hydration lattice originally present. Since the shape and extent of the iceberg would depend on the nature and disposition of protein side chains, if the latter have not been separated from each other by unfolding of the polypeptide backbone, these should continue to provide the framework for the reconstruction of the original hydration lattice once the disturbing denaturing influence has been removed. On the other hand, irreversible denaturation would follow after an unfolding of the fundamental polypeptide configuration, since a refolding into the highly specific original orientation is an improbable process.

It is perhaps of interest to note in connection with reversible denaturation that the pK_a of the $-N(CH_3)_2$ group attached to serum albumin showed changes in the expected direction. As was pointed out above, the pK_a changed from 1.7 to 3.3 upon addition of urea; when the urea was then dialyzed out for 24 hours, the pK_a returned to 1.85.

It has been known for some time that anions, in small amounts, can protect serum albumin against denaturation by urea or heat (*31*). If this protection arose from a stabilization or further extension of the hydration lattice due to the bound anion on the protein, one might expect the pK_a of the $-N(CH_3)_2$ group to be lowered even further in the presence of suitable anions. Some experiments were carried out, therefore, with small amounts of dodecyl sulfate anions and serum albumin; the observed pK_a was below 1.3, as compared to 1.7 when the protein was in water alone. Furthermore, if low concentrations of dodecyl sulfate were added to urea solutions, the pK_a, instead of being 3.3, as for urea alone, was returned downward to 2.4. All of these observations fit readily the view that polarizable organic molecules increase the order of water structures. It is reasonable, therefore, that, when bound to a protein surface, long-chain aliphatic anions might extend even further the lattice-ordered hydration layer. Other surprising effects of anions or neutral small organic molecules on serum albumin, such as the large changes in optical rotation produced by a small number of bound anions (*32*) or the marked effects of decanol and oleate on the dielectric increment of serum albumin (*33*), are also more readily visualized in terms of a reorientation of the hydration layer than on the basis of a rearrangement of the configuration of the peptide chains.

The literature also indicates that concentrated solutions of sugars and sugar alcohols inhibit the denaturation of some proteins (*34*). We have made, therefore, a few measurements of pK_a's of the $-N(CH_3)_2$ group attached to serum albumin in solutions of 40- to 60-percent sorbitol. It is certainly pertinent to note that the pK_a's dropped to 1.4 to 1.3.

In contrast to these stabilizers against denaturation, high hydrostatic pressures inactivate enzymes and cause coagulation of proteins (*35*). This effect is of course what one would expect in view of the indications cited above that denaturation involves a decrease in volume as the hydration icebergs are converted into liquid water. In recent years, the masking of hydrogens on proteins has been approached through studies of rates of exchange with deuterium (*36*). Many of the effects reported, such as increased rates of exchange in the presence of urea, can be readily interpreted in terms of changes of hydration structure, as well as of modifications in configuration of the protein chains. Of particular interest in this connection are the observations of Hvidt (*37*) on the marked decrease in rate of exchange of deuterium in ribonuclease as the temperature is lowered. Such behavior would seem very plausible on the basis of the iceberg viewpoint, since the extent of the rigid lattice structure should surely increase as the solution is cooled.

A similar effect of temperature on masking has been recently reported by Murayama (*38*) in experiments on the uptake of silver ion by crystallized dialyzed hemoglobin. Substantially more sulfhydryl groups became available as the temperature was raised from 0° to 38°C—that is, in terms of our viewpoint, as the iceberg melted (*39*).

Thus it is apparent that many of the specific phenomena that are included in the broad terms *denaturation* and *masking* can be interpreted very plausibly in terms of the behavior of the hydration sheath of protein molecules.

Cooperative effects. Since many aspects of the oxygenation reaction have been investigated, it is of interest to examine the oxygen-carrying proteins in some detail. From the "iceberg" point of view, the binding site of the deoxygenated protein may be visualized as having an aqueous covering sheath whose lattice structure is determined by the nature of the residues (and metal) at the active site and by the amino acid side chains in the vicinity of the site. Under appropriate conditions these crystalline water islands may be so extensive that they merge into an interwoven lattice. The subsequent attachment of an O_2 molecule to the binding site would then produce an incongruity in this lattice because of the larger size of O_2 as compared to H_2O and because of the differences in hydrogen-bonding properties. As a result, the hydration lattice might be disturbed for an appreciable distance around the active site. This disturbance could affect the hydration structure of neighboring sites and hence change their affinity toward oxygen molecules. In this way an S-shaped oxygenation curve may arise (Fig. 5).

There are several features of this model which seem more plausible than those recently proposed by others (*40, 41*). For one, cooperative interactions, which have been studied most extensively in hemoglobin, exist also in hemocyanin and hemerythrin, which do not contain heme groups and in which, therefore, the bulkiness of the heme can play no direct steric role. Furthermore, with hemocyanin, for example, the extent of interaction between sites depends very much on *p*H (*42*); one would anticipate changes in hydration as the charges on groups of the protein are varied. Likewise, one can interpret readily the effects on the affinity of hemoglobin for oxygen of salts which presumably change only the ionic strength (*43*), as well as the influence of specific ions (*44*) on the interactions between sites in hemocyanin. All of these substances could modify the

extent and nature of the lattice structure of the hydration sheath of the protein. In a similar vein, changes in solubility of hemoglobin upon oxygenation seem more plausible. The structure of the hydration lattice would depend on the state of oxygenation as well as, presumably, on the number, type, and position of amino acid side chains. When the interaction of the protein with solvent molecules in the hydration sheath is altered, one might reasonably expect differences in the interaction with solvent molecules in the liquid phase—that is, changes in solubility. Likewise, relatively small changes in composition of a hemoglobin —for example, the single different amino acid (*45*) in sickle-cell hemoglobin (half molecules)—could have the profound effect on solubility that they have because the nature of the hydration layer around one specific side chain could affect the structure of the lattice for some distance in its neighborhood.

It is also of interest to examine further certain interrelationships among properties of hemoglobin pointed out by Wyman and Allen (*40*). As these investigators have shown, there exists a parallelism of interactions between hemes when the process is oxidation-reduction and when it is oxygenation; when one heme is oxidized, the second follows along immediately, as in oxygen uptake. Likewise, there is a parallelism in interactions when the equilibrium involves carbon monoxide and when oxygen is the gas. On the other hand, in examining correlations between the Bohr effect and other properties of heme proteins, Wyman and Allen (*40*) point out that these changes in oxygen affinity with *p*H do not seem to be related to the change in bond type of the iron. Thus, myoglobin shows no Bohr effect, although oxygenation produces the same change in unpaired electrons of iron as it does in hemoglobin, which shows a large Bohr effect. Thus, if the Bohr effect is attributed to changes in the nature of the bonding of an imidazole side chain to the iron, as has been described by Coryell and Pauling (*46*), one must assume that a histidine-iron linkage does not occur in myoglobin. As an alternative explanation of these phenomena, Wyman and Allen (*40*) propose that the protein molecule changes its configuration on oxygenation, or oxidation, and that it is these changes which transmit the interactions between hemes or affect the acidity of certain amino acid residues.

It seems apparent that if we consider the "iceberg" viewpoint, characteristics of heme proteins are more readily interpretable. While the uptake of an oxygen molecule or the removal of an electron from the heme iron could conceivably alter the configuration or folding of peptide chains, it seems more plausible that these changes would influence the interaction of the iron and heme with the aqueous hydration sheath. (Certainly, Fe^{++} and Fe^{+++} in simple aqueous solution differ very greatly in their interaction with H_2O molecules). As indicated above, a disturbance at one point in the water lattice could, reasonably, affect the hydration structure for some distance in the vicinity. One might anticipate, therefore, changes in the oxidation or oxygenation characteristics of neighboring hemes, as well as of the acidity of acid-base groups of amino acid residues in the vicinity.

In these terms one can also understand more readily why nonheme oxygen carriers also show Bohr effects. Hemocyanins of the lobster and crab (*47*), for example, become more acidic on oxygenation; hemocyanin of the horseshoe crab (*Limulus*) does not. It could be, of course, that the copper is bound to imidazole in the first two cases and not in the latter. However, a more plausible explanation seems available in terms of differences in the structure of the hydration lattice, particularly when one notices that the extent of interaction between binding sites for oxygen parallels the magnitude of the Bohr effect, being large for lobster and crab and small for *Limulus*. Along the same lines it is further of interest to note that interactions between sites in hemerythrin (*9*), the other class of nonheme oxygen-carrying pigment, are small (Fig. 6) and that, furthermore, this protein gives no evidence of a Bohr effect (*48*).

Thus it seems feasible to use a more unified interpretation of many aspects of the behavior of all classes of oxygen-carrying pigment in terms of the character of the "frozen" water in these proteins.

Conclusion

We have thus reexamined a variety of unique features of protein behavior and have seen that a thread of likeness can be drawn through them when the hydration sheath is viewed as an icelike lattice. These correlations in interpretation of behavior serve to emphasize the important role played by the solvent in fixing the structure and properties of the solute molecule, as well as the influence of the solute in imposing a structure on the solvent. It is this mutual interaction which has perhaps not been fully appreciated in the interpretation of the behavior of proteins in solution. The topics reviewed in this light in this article were representative but hardly exhaustive. They will undoubtedly suggest other phenomena which might be profitably reinterpreted in terms of the concepts discussed here (*49*).

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The Conservation of Intellectual Talent

The reasons why some able students do not attend college and the uses of scholarships are assessed.

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Estimates of the number of highly talented students who fail to go to college are alarming. Even if we take the most conservative of the available estimates (*1*), about 34,000, or 28 percent, of the highest-ranking tenth of the nation's high school graduates do not enter college as full-time students. For students in the highest 30 percent in respect to ability, the estimated number not going to college increases fourfold. In 1955 one study (*2*) reported that some 150,000 students in the top 30 percent of ability failed to go to college, but would have gone if scholarships had been available.

These figures suggest the need for more financial aid. Certainly existing funds are small compared with available estimates of the number of drop-outs among students of high ability, and who could be induced to go to college by financial aid. Fortunately, a national scholarship competition has features which tend to reduce the number of students who drop out after high school (*3*). Public recognition of the excellent performance of high-scoring students seems to motivate both the students and scholarship donors. Holland and Stalnaker (*4*) report that 98.7 percent of a group of near winners in the first National Merit Scholarship program went to college, and that approximately 65 percent of these students obtained scholarships from other sources. Students who rank high in any nationwide testing program become highly visible; as a consequence, they are stimulated to go to college and they frequently attract offers of scholarships from colleges and other sources. Thus loss is reduced.

Previous appraisals of talent loss were made before the initiation of the large-scale Merit Scholarship program. Under present conditions, the number of drop-outs among students of high ability is only half as large as the lowest figure estimated in earlier studies. The second annual Merit Scholarship program included a greatly enlarged sample of very able students. Over 166,500 high-school seniors in some 12,500 secondary schools took the initial qualifying test, and the top-scoring 15,000 students from this group were surveyed in respect to their college-going behavior. This population provides the best available means for appraising the current talent loss and for identifying the social and psychological factors which contribute to it (*5*).

In the present study, the amount of talent loss which occurs under existing conditions was estimated from the number of near winners in the 1957 program who failed to enroll in college. The study also sought to estimate the number of drop-outs who might attend college if additional scholarships were available.

Students ranking in the top 5 or 10 percent of the nation's youth cannot be expected to make full use of their talents without further specialized training. The loss of these students to higher education is an undeniable waste of the nation's intellectual talent. To throw light

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on the factors underlying this waste, the present sample was studied to ascertain those attributes which differentiate drop-outs from college-attenders. A knowledge of the environmental and personal factors contributing to withdrawal from higher education is necessary if we are to devise effective methods for reducing talent loss.

Sample

The results reported in this study are based on a survey of a stratified random sample of 14,945 top-scoring students who took the qualifying test (Scholastic Qualifying Test) in the 1957 Merit program (*6*). The total group was composed of three classes of students: 7690 high-ranking students who received a letter of commendation; 6428 finalists, who received a Certificate of Merit; and 827 Merit Scholars, who received monetary stipends. These groups are mutually exclusive. The designated stratum samples included 47 percent of the commended group, and 100 percent of the finalists and Scholar groups. Returns were received from 80, 80, and 94 percent, respectively, of the designated stratum samples. Though some bias resulting from nonresponse can be expected, no exact estimate of it can be made since a follow-up survey among nonrespondents has not been attempted.

It is important to note that the population of 15,000 students surveyed here represents the students scoring highest within each of the states and territories. Students from each state were ranked on the basis of their scores in the scholastic Qualifying Test, and the number designated for recognition in each state was arbitrarily made proportionate to the number of seniors in the public high schools of that state. A national scholarship program designed to help students throughout the nation must almost of necessity distribute recognition and awards to students in proportion to the state's population of high-school seniors. This feature of the program makes it difficult to estimate the number of recoverable drop-outs from test score distributions which disregard state differences. On the other hand, the present sample is admirably suited for estimating the number of talented students salvageable under conditions likely to obtain in any federal scholarship program.

Despite the variations introduced by the principle of identifying excellence within each state, it is estimated that over 97 percent of the population of 15,000 students are in the top 6 percent of the nation's high-school seniors in respect to verbal ability. The group is less highly selected in respect to mathematical ability, since the test scores used to rank students were composites which weighted verbal scores twice as heavily as mathematical scores. Nevertheless, it is estimated that about three-quarters of this population of very able students fall in the top 9 percent, by mathematical ability, of the nation's high-school seniors.

Table 1. Estimates of talent loss among students of high ability.

Source	Population	Date of graduation from high school	Estimated percentage not attending college
National Merit Scholarship program	Merit scholars ($N = 827$)	1957	0.2*
	Finalists ($N = 6428$)	1957	3.1
	Semifinalists ($N = 7690$)	1957	5.1
	Total ($N = 14,945$)	1957	3.9
Terman and Oden (*9*)	Highest 1 or 2 percent, by IQ, in California schools	1928	12
Phearman (*10*)	Highest 2 percent, by achievement tests, among Iowa high-school graduates	1947	8
Wolfle (*11*)	Highest 2.8 percent of high-school graduates on intelligence test	1953	39
Phearman (*10*)	Highest 9 percent of Iowa's high-school graduates	1947	36
Iffert (*1*)	Highest 10 percent in high-school graduating class	1950	28
Corcoran and Keller (*12*)	Highest 15 percent by IQ, of Minnesota high-school seniors	1950	33†
Wolfle (*11*)	Highest 8.8 percent of high-school graduates	1953	45
Educational Testing Service (*2*)	Highest 10 percent, by aptitude test, of public high-school seniors	1955	30
Iffert (*1*)	Highest 30 percent in high-school graduating class	1950	30
Wolfle (*11*)	Highest 31 percent of high-school graduates	1953	53
Educational Testing Service (*2*)	Highest scoring 30 percent of public high-school seniors	1955	47

* Two students awarded scholarships are having their scholarships held for 1 year.
† Percentage attending college within 4 years of graduation.

Estimates of Talent Loss

Table 1 presents estimates of talent loss among students of high ability. The first estimates in the table are those of drop-out rates for winners and near winners in the 1957 Merit program; the other estimates in the table are previous estimates of talent loss, which were based upon knowledge of the college-going behavior of students not participating in a national scholarship competition. The previous estimates vary considerably: for the top 2 or 3 percent, estimates of the drop-out rate vary from 8 to 39 percent; for the top tenth of the nation's high-school graduates, it has been estimated that between 28 and 45 percent do not go to college.

Most noteworthy is the fact that the drop-out rate of approximately 4 percent among the 15,000 very able students in the Merit program is half the figure given in the most conservative previous estimate. Among boys the estimated drop-out rate is 3.5 percent; among girls, 4.8 percent. In the present study a student was considered a drop-out if he failed to enroll as a full-time student in an accredited college in the quarter or semester immediately following high school graduation. About 66 percent of the drop-outs plan to get at least a bachelor's degree, so that if we were to follow these students for a longer period after their graduation from high school, we would find that the talent loss is even smaller.

It is believed that the extremely low drop-out rate among these students is a consequence of the public recognition that the near winners attain through

Table 2. Estimated percentage, by state, of 14,118 near-winners in the 1957 Merit program who did not enroll in college immediately.

Percent	State*	Percent	State*
0	District of Columbia (6.5)	4	Mississippi (49.0)
0	New Hampshire (1.0)	4	Oregon (19.0)
0	Nevada (23.0)	4	Pennsylvania (12.5)
1	New Jersey (6.5)	4	Texas (40.5)
2	Alabama (46.0)	4	Vermont (30.5)
2	Massachusetts (2.5)	4	Virginia (37.0)
2	Missouri (27.5)	5	California (17.0)
2	Montana (27.5)	5	Connecticut (2.5)
2	New York (5.0)	5	Georgia (43.5)
2	North Carolina (40.5)	5	Idaho (33.5)
2	North Dakota (30.5)	5	Iowa (12.5)
2	Rhode Island (30.5)	5	New Mexico (35.5)
2	Tennessee (38.5)	5	Oklahoma (38.5)
2	Territories (Alaska, Hawaii. Puerta Rico, Canal Zone)	6	Indiana (12.5)
		6	Kansas (25.5)
		6	Michigan (8.5)
3	Colorado (20.5)	6	West Virginia (45.0)
3	Nebraska (25.5)	8	Arizona (23.0)
3	Ohio (17.0)	8	South Dakota (30.5)
3	South Carolina (48.0)	9	Minnesota (4.0)
3	Wisconsin (8.5)	9	Utah (33.5)
4	Florida (35.5)	11	Arkansas (47.0)
4	Illinois (17.0)	11	Washington (12.5)
4	Kentucky (43.5)	14	Maine (12.5)
4	Louisiana (42.0)	15	Delaware (12.5)
4	Maryland (23.0)	17	Wyoming (20.5)

* Numbers in parentheses represent order of rank in regard to talent supply. The states and the District of Columbia were ranked 1 to 49, according to the percentage of registrants scoring 70 or above on the Selective Service Qualification Test given May through July, 1951 (*13*). A low number indicates a relatively high supply of talent.

their participation in the Merit program. An estimated 58 percent of the near winners who enrolled in college immediately held freshman scholarships with an average stipend of $602. Furthermore, it is estimated that 70 percent of the 14,118 near winners received at least one offer of scholarship aid from other sources. In a previous survey (*4*), about 30 percent of the 1956 near winners reported that they either received direct offers of scholarships or were aided in securing scholarships on their own initiative because of recognition received in the Merit program. In addition, some 11 percent of this group indicated that the recognition provided them with considerable emotional support; in many cases the students believed the honorary award had stimulated them to attend college. It is expected that any national scholarship program will similarly affect near winners. Runners-up who receive recognition will not only be more highly motivated to go to college, but they will also tend to attract offers of scholarships from private scholarship donors.

Table 2 shows that the drop-out rate varies considerably from state to state. The District of Columbia, New Hampshire, and Nevada are at one extreme, with an estimated zero percent of near winners dropping out, while at the other extreme are Maine, Delaware, and Wyoming, with an estimated 14 to 17 percent drop-out rate among near winners. The relatively high drop-out rates for Delaware, Maine, Washington, and Minnesota are of special interest since students in these states tend to rank high in ability level.

Role of Scholarships in Reducing Talent Loss

Most drop-outs indicate that the problem of financing a college education was a major factor in their decision not to enter college immediately. Over half (52 percent) of the near winners who did not go to college mentioned as one of their most important reasons, "It would cost more than my family could afford." Eighty percent replied "Yes" to the question, "Would you go to college if you had more money?" Some 84 percent of the drop-outs say they would certainly or probably accept a scholarship paying all their college expenses.

Although finances are a problem for these students, very few have resolved *not* to enter college. It is estimated that 84 percent of the drop-outs plan to do at least some college work. Sixteen percent plan to get Ph.D. or M.D. degrees, and an additional 20 percent plan to do at least one year of graduate work. It appears that the majority of the drop-outs have delayed, rather than definitely decided against, entering college.

In other words, of an estimated 600 drop-outs among the top 15,000 students in the 1957 Merit program, some 500 would have gone to college immediately if scholarships had been available. But 500 of these students who are now without prospects of scholarship assistance say that they are still planning to do at least some college work. To be sure, the delay between high school and college will be critical for some, who will never actually enroll. In 1955 an Educational Testing Service follow-up (*2*) of the top-scoring 10 percent of a sample of high-school seniors showed that of some 530 students planning to go to college, 15 percent failed to enroll the following fall. But even if we assume that of the 500 drop-outs now planning to attend college a quarter will not go, the drop-out rate would be only about one percent of the near winners.

Considerably more than 500 scholarships would have been required to send all the drop-outs who want further education to college immediately. This paradox arises because at present it is not possible to differentiate between the student who will not enroll immediately if he does not get a scholarship and the student with comparable financial resources who will manage to go to college without assistance. If it were possible to differentiate these two groups of students in the selection stage, scholarship funds could be used more efficiently to forestall delay in entering college.

The chief contribution of an augmented scholarship program for the present population of students of high ability, it appears, would be to hasten, rather than increase, college enrollment. On the other hand, new scholarship funds could materially reduce talent loss if awards were offered to *less* highly talented students. The most important reservoir of wasted talent is found among students who rank between the 70th and 95th percentile in the distribution of ability. Above this level the loss is, as we have seen, relatively small. The 70th percentile in ability is suggested because various authorities have estimated that students above this level of ability are the students who profit most from a college education.

Factors Contributing to Talent Loss

Table 3 compares drop-outs and college-attenders with respect to 17 attributes which previous research had found to differentiate drop-outs at lower ability levels. The most striking differences are found in the vocational and educational aspirations of the different classes of near-winners. Only about a third of the drop-outs plan to do postgraduate study, whereas about two-thirds of the college-attenders plan such study. About a third of the students not enrolling in college immediately have selected vocations which do not require the bachelor's degree; only 10 percent of the college-attenders have selected such vocations. Contrary to expectations, drop-outs are no more undecided in their vocational choices than are college-attenders.

The second feature which stands out in Table 3 is the difference in cultural stimulation between the homes of drop-outs and the homes of college-attenders. For the most part, the parents of drop-outs have not attended college and have fewer books in the home. The fathers of students not going to college tend to be employed in middle- or low-income occupations.

Talent loss among the near-winners does not appear to be the result of a lack of counseling or guidance in the schools. Drop-outs report receiving relatively more encouragement from their teachers and guidance counselors than do college-attenders. On the other hand, the parents of drop-outs—who presumably must assume the financial burdens—encouraged college attendance less frequently than did the parents of college-goers. Drop-outs also tend to have more close friends who are not going to college. In general, however, nine out of every ten drop-outs among the near winners received some encouragement to attend college.

As might be expected, drop-outs tend to have slightly lower aptitude test scores than do the near-winners who enrolled in college with scholarships. On the other hand, the large proportion of drop-outs whose aptitude test scores place them in the top two percent of the national ability continuum attests to the seriousness of losing such promising students.

At least part of the talent loss may be attributed to lack of initiative among drop-outs. Only 44 percent of the drop-outs made two or more applications for scholarships, whereas 74 percent of the near-winners enrolling with scholarships made this many applications. Mollenkopf and Dear (7) have previously shown that the likelihood of receiving a scholarship offer increases rather dramatically with the number of applications made.

The results confirm previous findings (2) that the drop-out rate is higher for girls than boys, and that drop-outs tend to have had less mathematics in high school. However, very few, if any, lack the prerequisites for college. Eighty-four percent of the drop-outs took high-school courses preparing them for college.

Discussion

Although the present analysis demonstrates that the current loss of talent among the top 5 percent of the high-school-senior population is less than previous studies have estimated, these results do not justify complacence. There is clearly a need for the continuation of all current scholarship programs and for additional financial aid. True, the need probably will not be critical among students who receive recognition in existing scholarship programs, provided such programs are continued. Most of these students will go to college, many of them with scholarships. But there remains a large number of talented students who drop out of school because of their inability to finance a college education. There is particularly a need for additional funds to recover those students who rank between the 70th and 95th percentiles on the ability continuum. Talented drop-outs who are only "second best" are at present the most promising population in which governmental financial aid programs can effect a reduction in talent loss. Special effort may be required to dispel the notion that only the valedictorian deserves assistance. Particularly deserving of consideration are those needy students who are

Table 3. Differences between drop-outs and near-winners who attended college, among 14,118 participants in the 1957 Merit program.

Attribute	Estimated percent of near-winners having indicated attribute		
	Enrolled in college without scholarship	Enrolled in college with scholarship	Drop-out
Cultural stimulation			
200 or more books in home	69	58	51
Mother had at least some college	62	52	33
Father had at least some college	71	57	38
Father in professional or managerial occupation	72	54	37
Encouragement to attend college			
Mother encouraged student to attend	99	98	89
Father encouraged student to attend	99	97	85
Teachers gave "quite a lot" of encouragement	76	80	88
All of student's closely associated peers going to college	48	38	21
Scholastic Qualifying Test score			
Verbal score in top 2 percent of national senior norms	76	79	72
Quantitative score in top 2 percent of national senior norms	45	52	44
High school preparation			
Took college preparatory curriculum	93	92	84
Took 8 or more semesters of mathematics	61	61	46
Vocational and educational aspirations			
Planning to enter vocation requiring bachelor's degree	86	90	66
Student's vocational plans are tentative or undecided	60	56	56
Planning to do at least 1 year of postcollege graduate study	61	69	36
Personal characteristics			
Male	64	66	56
Applied for two or more scholarships (exclusive of NMS program)	41	74	44

highly motivated to pursue higher education but who rank slightly below the top decile on the usual measures of college aptitude. Scholarship funds for the large number of potential drop-outs among the "second best" are in short supply.

Further research is also required. What impact, if any, does a national scholarship competition have upon students who compete but fail to win recognition? Are these students stimulated to develop their talents, or are they diverted into occupations less commensurate with their ability level? How can we devise better methods for identifying the potential drop-out while he is still in high school? What resources can be marshaled to lessen the talent loss arising from parental attitudes and cultural deficits? (*8*).

References and Notes

1. R. E. Iffert, *Coll. and Univ.* 31, 435 (1956).
2. Educational Testing Service, *Background Factors Relating to College Plans and College Enrollment among Public High School Students* (Educational Testing Service, Princeton, N.J., 1957).
3. In this paper the term *drop-out* generally refers to a high-school graduate who does not enroll in college. In the discussion of drop-outs among participants in the Merit program, the term refers to high-school graduates who failed to enroll in an accredited college in the quarter or semester *immediately* following graduation from high school, or to students who enrolled but withdrew before completing a full quarter or semester.
4. J. L. Holland and J. M. Stalnaker, *J. Higher Educ.* 28, 361 (1957).
5. The top-ranking 5 percent of the senior class in each participating high school was tested without charge. Further, the second annual program allowed additional seniors to take the qualifying test by paying a fee of $1; this provision in part accounts for a threefold increase in the number of participants in the second year. Since an estimated 88 percent of the 1956 senior population attended one of the 10,388 high schools in the first year's program, it is estimated that a minimum of nine out of every ten senior students were screened in the 1957 talent search.
6. The ability levels of 241 students were difficult to estimate (because of incomplete aptitude test scores or follow-up test performance incommensurate with performance on the initial test); these students were not surveyed and are not considered a part of the top 15,000 students referred to.
7. W. G. Mollenkopf and R. E. Dear, *An Analysis of Factors Affecting Financial Aid-Offers and Awards* (Educational Testing Service, Princeton, N.J., 1957).
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12. M. Corcoran and R. J. Keller, *College Attendance of Minnesota High School Seniors* (Bureau of Institutional Research, Univ. of Minnesota, 1957).
13. C. C. Cole, Jr., *Encouraging Scientific Talent* (College Entrance Examination Board, New York, 1956), p. 83.

News of Science

NASA Absorbs NACA

On 30 September the personnel, facilities, and research activities of the 43-year-old National Advisory Committee for Aeronautics were incorporated into the National Aeronautics and Space Administration. With this action, NASA is effectively "in business."

The action came nearly a month sooner than the statutory requirement that the transfer, by proclamation in the Federal Register, be made not later than 90 days after the date of enactment of the Space Act (President Eisenhower signed it 20 July). T. Keith Glennan, administrator of NASA, said he would soon announce details of the NASA organizational structure.

The three main NACA laboratories will be renamed in the change-over to NASA. The Langley Aeronautical Laboratory at Langley Field, Va., will be renamed the Langley Research Center. The name of Ames Aeronautical Laboratory, Moffett Field, Calif., will be changed to Ames Research Center, and the Lewis Flight Propulsion Laboratory, in Cleveland, Ohio, to the Lewis Research Center. No change of name is pending for the High Speed Flight Station, Edwards, Calif.; Pilotless Aircraft Research Station, Wallops Island, Va., or the Plum Brook Research Reactor Facility, Sandusky, Ohio. NASA took over NACA headquarters in Washington.

Cooperative Education

The first nationwide study of cooperative education in American colleges and universities has been announced by Ralph W. Tyler, chairman of the Study Committee on Cooperative Education, and director of the Center for Advanced Study in the Behavioral Sciences, Palo Alto, Calif. The project is supported by a grant of $95,000 from the Fund for the Advancement of Education, a subsidiary of the Ford Foundation.

Approximately 60 colleges and universities now have programs of cooperative education for some or all of their students. Under the cooperative plan, students alternate periods of work in school and in industry as a regular part of their degree programs.

The cooperative plan was inaugurated in 1906 at the University of Cincinnati by the late Herman Schneider, dean of engineering. It has become a well-established type of engineering education and has been adopted in programs of business administration, education, science, and the liberal arts. Much of the growth of the plan has come since World War II.

The principal aim of the new study is to examine the educational merits of the work-study plan for college students. The investigation group hopes to learn something about the kinds of young people attracted to cooperative programs rather than to traditional programs, something about the kinds of students for whom the cooperative experience is particularly meaningful, and something about the outcome in terms of readiness for permanent employment and readiness for effective participation in civic and community affairs.

The study also proposes to examine the economic values of cooperative education for students and for institutions operating the plan, and to examine the role of industry and business. Results of the study will be useful to officials of higher education, parents, high-school guidance counsellors, and industry.

Charles F. Kettering, inventor and former director of research for General Motors, serves as honorary chairman of the Study of Cooperative Education. The professional staff of the study lists James W. Wilson, coordinator of educational research at the Rochester Institute of Technology, as executive director and Edward H. Lyons, Industrial Coordinator at the University of Detroit, as associate director.

New Psychological Journal

A new journal, *Engineering and Industrial Psychology,* is scheduled to begin publication in the spring of 1959. It will be a quarterly periodical devoted to original investigations dealing with the adaptation of human tasks and working environment to the psychological and physiological attributes of human beings, and the application of psychological principles and research methods to the solution of personnel management problems. The editor is to be Lee W. Cozan, research psychologist with the Department of Health, Education, and Welfare. The publisher is Engineering and Industrial Psychology, Inc. P. O. Box 662, Washington 4, D.C.

Staphylococcal Infections

Early detection of staphylococcal infections in hospitals, rigid measures to prevent their spread, and increased research to find better methods of preventing and treating them have been recommended by the National Conference on Staphylococcal Disease. Staphylococcal infections which are acquired by hospital patients do not respond to the penicillin and other antibiotic drugs that kept them under control until recently.

The conference, cosponsored by the Public Health Service and the National Research Council, met at Atlanta, Ga., at the headquarters of the PHS Communicable Disease Center, 15–17 September. It was attended by delegates from 59 professional organizations and by specialists on various aspects of the infection problem.

The delegates agreed that the drug-resistant infection is now a problem in practically all hospitals, not only in the United States, but throughout the world. Serious epidemics, although infrequent, have cropped out unexpectedly in many hospitals.

Usually starting in surgical wards and in nurseries for newborn infants, the disease is spread through the hospital and out into the community by these patients, many of whom show no symptoms, such as boils and abscesses, until after they leave the hospital. Fear of causing public alarm which might deter persons from getting needed hospital care has caused some hospiatls to attempt to hide their problem. However, hospital administrators who attended the conference reported a growing awareness that open recognition of the problem will contribute to its control.

Because staphylococci are ubiquitous —it is estimated that over 50 percent of the population carry one or many strains on their skins and in their noses —and because the drug-resistant strains permeate hospitals and their personnel, the problem of preventing serious infection sifts down to finding how the dangerous strains are spread and building barriers against them. Although the delegates recognized that contaminated air and furnishings could be responsible for spreading the infection, the prevailing opinion was that personal contact is certainly one of the most common causes. Most of their recommendations were therefore concerned with reducing this cause.

NIH Awards

Research grants and fellowships totaling $42,665,767 were awarded during the months of July and August by the National Institutes of Health, U.S. Public Health Service. In all, 2793 grants were made to 489 institutions in 48 states, the District of Columbia, 2 territories, and 12 foreign countries.

More than half of the money, $23,415,056, went for the support of 1649 research projects concerned with allergy, infectious diseases, heart disorders, and various basic problems in the medical and biological sciences. Approximately one-third of the total number of research grants were for new projects, of which 224 are in the field of biological sciences basic to medicine. Individuals received 138 research fellowships awards for study in 68 institutions in 27 states, the District of Columbia, Hawaii, and the British Isles.

Science Legislation and the 85th Congress

Many bills that are of interest to the readers of *Science* are introduced in Congress each session; News of Science prints précis of such bills under the title Proposed Legislation. In the 3 October issue a review of part of this legislation was given. Here, the second half of this review is presented with notes on the history of the various bills as they went through the legislative process, and their status now, whether it be dead, pending, or public law. (S, Introduced in the Senate; HR, introduced in the House of Representatives; H Res, House Resolution; H Con Res, House Concurrent Resolution; S J Res, Senate Joint Resolution.)

General Scientific Activities

S 3609. Provide for research into problems of flight within and outside the earth's atmosphere. Johnson (D-Texas), Bridges (R-N.H.). Special Committee on Space and Astronautics.

Same as HR 12575. Became Public Law 568 [*Science* **128**, 582 (12 Sept. 1958)].

S 3294. Authorize Secretary of Commerce to enter into contracts for conduct of research in field of meteorology and authorize installation of government telephones in certain private residences. Magnuson (D-Wash.) (by request). House Interstate and Foreign Commerce.

No action.

S 3126. Create Department of Science and Technology; establish National Institutes of Scientific Research; authorize program of federal loans and loan insurance for college or university education in physical or biological sciences, mathematics, or engineering; authorize establishment of scientific programs outside U.S. Humphrey (D-Minn.), McClellan (D-Ark.), Yarborough (D-Tex.). Senate Government Operations.

No action. Some provisions in National Defense Education Act. (Public Law 864).

HR 11985. Establish within the National Science Foundation a National Scientific and Technical Information Service for the collection and dissemination of information in fields of science and technology. Celler (D-N.Y.). House Interstate and Foreign Commerce.

No action.

HR 13191. Require Commissioner of Education to encourage, foster, and assist in establishment of clubs for boys and girls especially interested in science. Wright (D-Tex.). House Education and Labor.

Passed, signed by the President (Public Law 875).

HR 12821. Require the Surgeon General to undertake a special research program on cystic fibrosis. Broomfield (R-Mich.). House Interstate and Foreign Commerce.

No action.

S 2967. Provide for establishment of National Science Academy; a program of scientific scholarships; encourage study of mathematics and science by assisting states in providing science education. Gore (D-Tenn.). Senate Labor and Public Welfare.

No action.

HR 11392. Create a Department of Science and prescribe its functions and establish a U.S. Science Academy within such department. Christopher (D-Mo.). House Government Operations.

No action.

S 3110. Establish Commission on Establishment of a United States Academy of Science. Potter (R-Mich.). Senate Armed Services.

No action.

HR 10293. Establish a national scien-

tific research reserve fund. Dawson (D-Ill.). House Interstate and Foreign Commerce.

No action.

HR 520. Provide for printing as a House document the statement entitled "Introduction to Outer Space." Arends (R-Ill.). House Administration.

No action.

S 3281. Amend Housing Act of 1950 to provide for loans to colleges and universities for science equipment and facilities. Thye (R-Minn.). Senate Banking and Currency.

No action.

HR 13091. Authorize expenditure of funds through grants for support of scientific research. Harris (D-Ark.). House Interstate and Foreign Commerce.

No action.

Federal Agencies

HR 11805. Promote the national defense by authorizing the construction of aeronautical research facilities by the National Advisory Committee for Aeronautics necessary to the effective prosecution of aeronautical research. Kitchin (D-N.C.). House Armed Services.

Passed, signed by the President (Public Law 617).

HR 11913. Amend the Public Health Service Act to authorize grants for research and teaching facilities for existing and new medical, dental, and public health schools; extend title VII of that act (re health research facilities) for an additional 3-year period. Roberts (D-Ala.). House Interstate and Foreign Commerce.

No action.

HR 12844. Create an independent Federal Aviation Agency to provide for safe and efficient use of airspace by both civil and military operations, and to provide for the regulation and promotion of civil aviation in such manner as to best foster its development and safety. Church (R-Ill.). House Interstate and Foreign Commerce.

No action, but a similar bill was passed and signed by the President (Public Law 726).

S 3632. Amend Public Law 85-162 to increase authorization for appropriations to the Atomic Energy Commission in accordance with section 261 of Atomic Energy Act of 1954, as amended. Anderson (D-N.M.). Joint Committee on Atomic Energy.

House bill (HR 12009) substituted, passed by House and Senate. (Public Law 412).

HR 12051. Provide for establishment of Bureau of Older Persons within the Department of Health, Education, and Welfare; authorize federal grants to assist in development and operation of studies and projects to help older persons. Libonati (D-Ill.). House Education and Labor.

No action.

HR 11860. Amend the act of 3 March 1915, as amended, to increase the scope of the activities of the National Advisory Committee for Aeronautics (renamed in this act the National Advisory Committee for Aeronautics and Astronautics), to establish in the Congress a Joint Committee on Astronautics, and for other purposes. Fulton (R-Pa.). Select Committee on Astronautics and Space Exploration.

No action.

S 3946. Amend provisions of Public Health Service Act re grants for hospital construction to include institutions for care and treatment of mentally retarded. Yarborough (D-Tex.), Proxmire (D-Wis.). Senate Labor and Public Welfare.

No action.

S 3588. Amend title VI of the Public Health Service Act, as amended, in order to make certain clinics in rural areas eligible for federal aid to diagnostic or treatment centers. Payne (R-Me.), Flanders (R-Vt.). Senate Labor and Public Welfare.

No action.

HR 11414. Amend section 314(c) of Public Health Service Act, to authorize Surgeon General to make certain grants-in-aid for support of public or non-profit educational institutions which provide training and services in fields of public health and in administration of state and local public-health programs. Rhodes (D-Pa.). House Interstate and Foreign Commerce.

Passed, signed by the President (Public Law 544).

S 3593. Amend the Atomic Energy Community Act of 1955 in order to authorize the Atomic Energy Commission to dispose of certain property for college purposes. Gore (D-Tenn.), Kefauver (D-Tenn.). Joint Atomic Energy.

No action.

S 3604. Amend the act of 3 March 1915, which established the National Advisory Committee for Aeronautics, and establish the National Astronautics Agency. Case (R-S.D.). Special Committee on Space and Astronautics.

No action, but a similar bill (HR 12575) became law (Public Law 568) [*Science* **128**, 582 (12 Sept. 1958)].

Conservation

S 3619. Establish a National Wilderness Preservation System for the permanent good of the whole people, to provide for the protection and administration of the areas within this system by existing federal agencies and for gathering and dissemination of information to increase the knowledge and appreciation of wilderness for its appropriate use and enjoyment by the people, to establish a National Wilderness Preservation Council. Neuberger (D-Ore.). Senate Interior and Insular Affairs.

No action.

S 3753. Provide that the Secretary of Interior shall develop and carry out an emergency program for eradication of starfish in Long Island Sound and adjacent waters. Bush (R-Conn.). Senate Interior and Insular Affairs.

No action.

S 3898. Authorize the establishment of the Indiana Dunes National Monument. Douglas (D-Ill.). Senate Interior and Insular Affairs.

No action.

HR 13138. Amend act of 10 March 1934 to provide for more effective integration of a fish and wildlife conservation program with federal water-resource developments. Boykin (D-Ala.). House Merchant Marine and Fisheries.

Passed, signed by the President (Public Law 624).

S 3695. Authorize an increased program of research on forestry and forest products. Humphrey (D-Minn.). Senate Agriculture and Forestry.

No action.

S 3582. Authorize the establishment of a Youth Conservation Corps to provide healthful outdoor training and employment for young men and to advance the conservation, development, and management of national resources of timber, soil and range, and of recreational areas. Humphrey (D-Minn.), Murray (D-Mont.), Neuberger (D-Ore.), Proxmire (D-Wis.), Jackson (D-Wash.), Senate Labor and Public Welfare.

No action.

Commerce

HR 10266. Extend for 1 year certain programs established under Domestic Tungsten, Asbestos, Fluorspar, and Columbium-Tantalum Production and Purchase Act of 1956. Aspinall (D-Colo.). House Interior and Insular Affairs.

No action, but a similar bill (S 3186) was vetoed by the President.

HR 7454. Amend the Tariff Act of 1930 to provide for free importation by colleges and universities of sound recordings and film to be used by them in certain nonprofit radio and television broadcasts. Eberharter (D-Pa.). House Ways and Means.

Passed. signed by the President (Public Law 458).

S 3892. Stabilize production of copper, lead, zinc, acid-grade fluorspar, and tungsten from domestic mines by providing for stabilization payments to producers of ores or concentrates. Murray (D-Mont.). Senate Interior and Insular Affairs.

No action, but a similar bill (S 4036) passed by Senate was killed by the House on 21 August.

HR 10404. Amend Federal Food, Drug, and Cosmetic Act for protection of public health, by prohibiting new food additives which have not been adequately pretested to establish their safe use under conditions of their intended use. Williams (D-Miss.). House Interstate and Foreign Commerce.

No action, but a similar bill (HR 13254) was passed (Public Law 929).

HR 12771. Restore (for 1 year) the duties on aluminum and aluminum products established in the Tariff Act of 1930. Baker (R-Tenn.). House Ways and Means.

No action.

HR 13069. Stabilize production of copper, lead, zinc, acid-grade fluorospar, and tungsten from domestic mines. Aspinall (D-Colo.). House Interior and Insular Affairs.

No action.

S 3900. Liberalize tariff laws for works of art and other exhibition material. Javits (R-N.Y.). Senate Finance.

No action.

S 3595. Amend section 406 of the Federal Food, Drug, and Cosmetic Act in order to provide that maximum concentrations for certain color additives used in coloring oranges be prescribed by regulation. Holland (D-Fla.). Senate Labor and Public Welfare.

No action.

S 3537. Encourage discovery, development, and production of manganese-bearing areas in U.S., its territories and possessions. Martin (R-Iowa). Senate Interior and Insular Affairs.

No action.

Miscellaneous

S 2994. Provide for holding a White House Conference on Aging to be called by President of U.S. before 31 December 1958, to be planned and conducted by Special Staff on Aging of the U.S. Department of Health, Education and Welfare with assistance and cooperation of other agencies of that department and of other departments and agencies represented on Federal Council of Aging; assist several states in conducting similar conferences on aging prior to White House Conference on Aging. Neuberger (D-Ore.), Kefauver (D-Tenn.). Senate Labor and Public Welfare.

No action, but a similar bill (HR 9822) was passed and signed by the President (Public Law 908).

H Res 556. Express sense of House of Representatives in favor of continued testing by U.S. of nuclear and thermonuclear devices. Hillings (R-Calif.). Joint Committee on Atomic Energy.

No action.

HR 11838. Supplement the act of 3 July 1952 by providing for construction of a full-scale demonstration plant in Ventura County, Santa Barbara County, San Luis Obispo County, or Monterey County, Calif., for the production of fresh water from salt water. Teague (R-Calif.). House Interior and Insular Affairs.

No action, but a similar bill (SJ Res 135) became Public Law 883.

S 3539. Amend part VI of subtitle C, title 10, U.S. Code to authorize Secretary of Navy to take possession of naval oil shale reserves. Allott (R-Colo.). Senate Armed Services.

No action.

H Con Res 325. Authorize Joint Committee on Atomic Energy to print for its use 10,000 copies of the public hearings on the physical research program as it relates to atomic energy. Price (D-Ill.). House Administration.

Became law 24 July, 1958. No presidential approval required.

HR 11363. Amend Communications Act of 1934 to prohibit subliminal projection by television stations. Hosmer (R-Calif.). House Interstate and Foreign Commerce.

No action.

Résumé

Of the 94 bills described in *Science* since last January, 69 have been reported on in this article and the one published in the 3 October issue. Of these 69, 46 received no action, 20 were passed in some form, and of the remaining three, one was killed in Congress, one was vetoed by the President, and the provisions of the last were dropped from a similar but more inclusive bill.

News Briefs

The Atomic Energy Commission has announced that a new facility at Oak Ridge National Laboratory, designed to demonstrate on a pilot-plant scale the processing of long-lived radioactive fission products, has started preliminary operations. The $2.2 million facility, known as the Multicurie Fission Products Pilot Plant, will be used to isolate large quantities of radioisotopes for peaceful applications, principally in the industrial field.

* * *

A solar furnace designed for laboratory testing of materials for protecting soldiers against thermal effects of nuclear and other weapons has been placed in operation at Headquarters, Quartermaster Research and Engineering Command, Natick, Mass. The new furnace, the largest in the United States, produces a radiation flux sufficiently high to destroy materials and burn protected skin with exposure time of less than one second over a circular area 4 inches in diameter in a vertical plane. A solar image of this size is formed by an array of 180 concave, rectangular concentrating mirrors arranged on a spherical surface so that the images of all are superimposed at the target.

* * *

American colleges and universities are planning to build at least 172 new physics buildings in the near future, at an estimated cost of $240,310,000, according to a survey made by the American Association of Physics Teachers. The survey, which was conducted by the association's Committee on Design of Physics Buildings, covered 540 U.S. colleges and universities where it is possible to obtain a major in physics.

* * *

Nagoya University in central Japan plans to establish a cosmic ray research station equipped with a reflecting telescope. The telescope, which is to be completed within 2 years, will be 43 feet long and 16.5 feet in diameter, with a mirror 13.2 feet in diameter. The instrument was designed by Yatarc Sekido of the university.

* * *

Reports and Analyses of Satellite Observations, sixth in the International Geophysical Year Satellite Report Series, has been published by IGY World Data Center A, National Academy of Sciences, Washington 25, D.C. It is available from the academy's Publications Office for $1 a copy.

* * *

Science Explores our World is a report of the International Geophysical Year programs prepared for secondary school students that sells for 15 cents per copy. It was written by Hugh Odishaw, executive director of the U.S. National Committee for the IGY, and published by Wesleyan University, Middletown, Conn., in cooperation with the U.S. National Committee.

* * *

Geodesists are needed in various federal agencies in Washington, D.C., and throughout the United States, the U.S. Civil Service Commission has announced. The principal users are the Coast and Geodetic Survey, the Navy Hydrographic Office, the Army Map Service, the Inter-American Geodetic Survey, and the Aeronautical Chart and Information Center. The salaries range from $4040 to $12,770 a year. Further information and application forms may be obtained at many post offices throughout the country, or from the U.S. Civil Service Commission, Washington 25, D.C.

Scientists in the News

LAURENCE H. SNYDER, president of the University of Hawaii and retiring president of the AAAS, has been named president of the Tenth Pacific Science Congress, which will be held in Honolulu in 1961.

WILLIAM W. GREULICH, head of the department of anatomy at Stanford University, is spending 6 months in East Africa as a senior Fulbright lecturer at Makerere Medical School, Kampala, Uganda, He is working there in the department of anatomy and in the Medical Research Council's Infant Malnutrition Unit, where he is collaborating with the director, R. F. A. Dean, in an investigation of the effects of kwashiorkor on the growth and development of African children. Gruelich will return to Stanford in January.

The Smithsonian Institution has announced the selection of A. C. SMITH as the director of the Museum of Natural History of the U.S. National Museum. Smith has been program director for systematic biology with the National Science Foundation. Prior to his affiliation with NSF, he was for 8 years curator of the division of phanerogams in the Smithsonian's department of botany. He now returns to the institution to direct the bureau that includes the departments of anthropology, zoology, botany, and geology. Smith will continue his scientific work in phanerogams.

Two awards for outstanding service to forestry were made at the 58th annual meeting of the Society of American Foresters held in Salt Lake City, Utah, on 1 October 1958. The Sir William Schlich Memorial Medal for distinguished service to forestry was awarded to B. FRANK HEINTZLEMAN of Juneau, Alaska. Governor of Alaska during the period 1953–56, Heintzleman was previously for 16 years regional forester in Alaska for the U.S. Forest Service.

The second award, for biological research contributing to the advancement of forestry, was made to NICHOLAS T. MIROV of the California Forest and Range Experiment Station at Berkeley. His outstanding research project was an investigation of the resinous substance of 80 species of pine trees.

ELIZAH ADAMS, formerly associate professor of pharmacology at the New York University College of Medicine, has joined the faculty of the Saint Louis University School of Medicine as professor of pharmacology and director of the department.

Also at Saint Louis, RENE WEGRIA, formerly associate professor of medicine at Columbia University College of Physicians and Surgeons, has become professor of internal medicine and director of the department.

J. LAURENCE KULP, professor of geochemistry and head of the Geochemistry Laboratory at Columbia University, will spend the coming academic year at Oxford University at a National Science Foundation senior postdoctoral fellow.

FRANK P. COSGROVE, formerly professor of pharmacy at Loyola University, has joined the staff of the College of Pharmacy at the University of Texas.

The International Trust for Zoological Nomenclature has announced that it has accepted with regret the resignation of FRANCIS HEMMING as a member of the trust and as managing director and secretary. Lt. Col. F. J. GRIFFIN, who is an original member of the trust, has been appointed managing director and secretary. R. V. MELVILLE, who has been acting assistant manager, has been appointed scientific controller, with responsibility for the scientific and editorial work hitherto performed by Hemming.

GIUSEPPE SERMONTI of the Institut Superiore di Sanita, Rome, Italy, is spending September, October, and November with S. G. Bradley, department of bacteriology and immunology, University of Minnesota. He will be in David Bonner's laboratory at Yale University during December. Sermonti is pursuing his work on the genetics of *Streptomyces coelicolor,* and in particular attempting to correlate his findings with those of workers in America.

G. L. PICKARD of the University of British Columbia, a professor in the department of physics and a professor of physical oceanography, has been appointed director of the university's Institute of Oceanography. He succeeds W. A. CLEMENS, who becomes emeritus professor and special lecturer in zoology.

ALBERT V. CREWE has been appointed director of the Particle Accelerator Division of the Argonne National Laboratory. Crewe has been technical director of the synchrocyclotron at the University of Chicago and an assistant professor in the university's department of physics and Enrico Fermi Institute for Nuclear Studies.

PAUL A. MILLER, meteorologist, has retired from the U.S. Weather Bureau. Miller has been closely identified with the development of aviation weather services since his entry into the Weather Bureau in 1925. He has served at weather stations in Macon, Atlanta, Davenport, and Indianapolis, but has spent most of his meteorological career at the Weather Bureau's central office in Washington, D.C.

Among Miller's many contributions to the improvement of aviation weather services throughout his career was the development of the Weather Bureau's manual of surface observation procedures. This weather observation handbook has been used daily by thousands of observers throughout the country and is now in its seventh edition.

In 1952 Miller was project leader in charge of the remodeling of the nationwide network of Weather Bureau Flight Advisory Weather Service Centers. In this service reorganization, many improved aviation weather centers were established, and new service techniques then introduced are still in use today.

In 1919 Miller enrolled at Purdue University but had to interrupt his university education in 1922 without having acquired a degree. He is returning to Purdue in order to complete his courses leading to a degree in chemistry.

MATHEW ROSS, psychiatrist, formerly of Beverly Hills, Calif., took office in September as medical director of the American Psychiatric Association, Washington, D.C. He succeeds DANIEL BLAIN, who resigned on 1 September. In addition to his private practice, Ross was assistant clinical professor of psychiatry, and also of psychology, at the University of California Medical Center in Los Angeles.

C. KINNEY HANCOCK, professor of chemistry at the Agricultural and Mechanical College of Texas, has received the 1958 award of $1000 from the Association of Former Students of Texas A. and M. in recognition of research performed in addition to teaching duties.

The University of Mississippi has two new faculty members: GEORGE H. DUFFEY, from South Dakota State College, professor of chemistry and physics; and RUSSELL W. MAATMAN, Socony–Mobil Oil Company, associate professor of chemistry.

B. CINADER has resigned as principal scientific officer in the department of experimental pathology at the Agricultural Research Council Institute of Animal Physiology at Babraham, Cambridge, England, to accept a post as head of the subdivision of immunochemistry in the Ontario Cancer Institute and associate professor in the department of medical biophysics of the University of Toronto, Toronto, Canada.

The American Sociological Society's MacIver lectureship for 1958–59 has been awarded to REINHARD BENDIX, research associate at the University of California's Institute of Industrial Relations, for his book, *Work and Authority in Industry*. The presentation took place during the society's recent annual meeting at the University of Washington. The annual lectureship, named for Robert N. MacIver, former Lieber professor of sociology at Columbia University, is granted to the author, or authors, of a publication which has contributed outstandingly to the progress of sociology during the two preceding years. The winner receives $500 and an invitation to deliver a lecture on his work to a selected group of sociologists. No award was made last year.

BERNARD LEWIS is the first recipient of the Bernard Lewis Medal of the Combustion Institute. The gold medal, newly established by the institute to honor a major contribution to the science of combustion, was recently presented to Lewis at the opening meeting of the seventh International Symposium on Combustion at the Royal Institution, London, England. He was cited for "brilliant research in the field of combustion, particularly on minimum ignition energy." Lewis has served as president of the Combustion Institute since its incorporation in 1954. He is also president of the consulting firm, Combustion and Explosives Research, Pittsburgh, Pa.

Another gold medal, the Alfred C. Egerton Medal, was awarded to ALFRED C. EGERTON, professor emeritus of the Imperial College of Science and Technology, London, and chairman of the British Section of the Combustion Institute, "for his distinguished, continuing, and encouraging contributions to the field of combustion."

The Combustion Institute Silver Medal was given to SEIICHIRO KUMAGAI and HIROSHI ISODA of the University of Tokyo, Japan, in recognition of "an outstanding paper" presented at the Sixth Symposium on Combustion at Yale University in 1956.

The Postgraduate Division of the prosthetic department of the New York University College of Dentistry has announced a reception and dinner honoring JOSEPH S. LANDA "for his 33 years of leadership as a teacher, clinician and researcher in dentistry and for his humane, dedicated and benevolent service in the interests of his colleagues, his community and his country." The dinner will take place on 22 January 1959 at the Hotel Belmont Plaza in New York. The subscription is $10. Reservations should be mailed to: Dr. Sidney I. Silverman, Chairman, 80 Park Ave., New York 16, N.Y.

ROBERT W. BATEY has been appointed director of food technology for Foster D. Snell, Inc., New York. Formerly Batey was associated with the George S. May Company as a consultant for the installation of business control systems and at Tenco, Inc., soluble coffee processors, as head of the Process Control Section.

DONALD C. GREAVES, associate professor of psychiatry at the University of Oklahoma School of Medicine, has accepted an appointment as chairman of the department of psychiatry at Kansas University Medical Center.

The American Meat Institute Foundation has selected BETTY M. WATTS, professor of foods and nutrition at Florida State University, as recipient of the F. C. Vibrans' Senior Scientist Award for 1958.

H. O. HENDERSON of West Virginia University has been presented with the $1000 Teaching Award in Dairy Production of the National Dairy Products Corporation.

G. WILLIAM SCHNEIDER, professor of horticulture at North Carolina State College, has been appointed head of the horticulture department at the University of Kentucky.

RICHARD B. MARSTON is transferring from the Intermountain Forest and Range Experiment Station to the Central States Forest Experiment Station at Columbus, Ohio, where he will be project leader in watershed management research for Ohio. Marston has been with the Forest Service for 19 years, all of them spent at the Intermountain Station. He is leaving the position of acting leader of the Wasatch Research Center at Ogden, Utah.

JOSEPH M. GINSBURG has returned to the United States after 2 years in foreign service and has resumed his duties at Rutgers University and the New Jersey Agricultural Experiment Station as research specialist in entomology, toxicology. He has been fulfilling a State Department Point-4 assignment in Israel, where he was adviser to the Israeli Ministry of Agriculture in toxicology and plant protection problems.

BERTRAM G. WOODLAND has been appointed associate curator of economic geology at the Chicago Natural History Museum. Woodland has been an assistant professor at Mount Holyoke College, where he taught geology, mineralogy, and geography. He has also acted as a consultant for Petroleo Brasileiro Depex of Rio de Janeiro and the Vermont Geological Survey. His field work has included geological studies in central France and in Great Britain.

Recent Deaths

WILLIAM A. ADOLPH, New Haven, Conn.; 68; biochemist who went to China in 1915 as a chemistry instructor at Cheeloo University, Tsinan; president of Yenching University in Peiping, 1947; taught at the universities of Nebraska and Illinois, at Yale and Cornell universities, at the American University in Beirut, Lebanon; 23 Sept.

JANET S. BALDWIN MAIER, New York, N.Y.; 50; head of the children's cardiac clinic at Bellevue Hospital since 1944 and chief of the Children's Cardiac Disease Clinic at Lenox Hill Hospital since 1945; associate professor of pediatrics at New York University College of Medicine; author of *Heart Catheterization*; 17 Sept.

HOWARD L. KING, Port Washington, N.Y.; 68; vice president and chief engineer of the Mason & Hanger-Silas Mason Company; directed construction of part of the Lincoln Tunnel and helped to build the Holland and Brooklyn-Battery tunnels; 21 September.

H. EVANS LEITER, New York, N.Y.; 51; urologist who was an early member of the artificial kidney team project in Mount Sinai Hospital; author of 30 papers on general surgery and urology; 12 Sept.

JOHN P. TURNER, Philadelphia, Pa.; 72; retired police surgeon who was the first Negro to be appointed to the Board of Public Education in 1935; former president of the National Medical Association; 15 Sept.

JOHN B. WATSON, Woodbury, Conn.; 80; founder of the behaviorist school of psychology, resigned as professor of psychology at Johns Hopkins University in the 1930's to enter the advertising business; retired in 1945 as a vice president of the William Estey Advertising Company; former vice president of the J. Walter Thompson agency; from a series of widely publicized experiments in the Phipps Clinic at Johns Hopkins, for the most part on animals, evolved a "psychology of behavior" based on the theory that the human being could be taught to be and to do almost anything—that he could be given personalities and habits; announced his conclusions, which he called "behaviorism," in a paper published in 1913, entitled *Psychology as the Behaviorist Views It*"; a founder of the "reinforcement theory," which holds that the response of the higher species, including humans, is guided by the presence or absence of a reward of reinforcement"; 5 Sept.

Book Reviews

Talent and Society. New perspectives in the identification of talent. David C. McClelland, Alfred L. Baldwin, Urie Bronfenbrenner, Fred L. Strodtbeck. Van Nostrand, Princeton, 1958. vii + 275 pp. $3.75.

The committee of social scientists which wrote this volume on utilization of talent turned away from traditional concerns with ability tests and thinking processes, exploring instead the values and styles of behavior that distinguish high achievers from low achievers. For example, high-achieving groups are much less fatalistic, and much more ready to break family ties in pursuing other goals.

This finding comes from the most interesting of the empirical chapters, Strodtbeck's study of family influences in transmitting "the American achievement ethic." Since Jews are high achievers by many criteria, and Italians low achievers, Strodtbeck examines differences in their family relations by several methods, including an ingenious technique for observing "how decisions are won" in family arguments. His striking intermixture of theory and evidence indicates that power relationships among parents and child determine the child's outlook on achievement. Power structures, in turn, depend on subcultural tradition, social class, and the out-of-home success of the male parent.

An intricate paper by Bronfenbrenner and others redefines the problem of measuring social sensitivity or insight. Their small-scale experiment cries out for replication; if the findings are confirmed, it will have outstanding implications for social psychology.

McClelland's summary of the four topical chapters shows that selecting the most promising young people is an inadequate solution to the problem of talent. He stresses the desirability of encouraging the individual to go into situations for which his values and styles of work are most adaptive. This replaces the concept of all-round potential with a concept of potential for specific roles. It is also suggested that we can modify the child's experiences so as to develop attitudes conducive to achievement in this culture, and that school and work situations can be modified to use value patterns that do not now lead to success. A typical question is: If school success is a prerequisite to responsibility and if school demands certain personal characteristics, may we not be eliminating individuals who lack these traits but whose other characteristics would make them highly successful in science, art, or public affairs? Questions may be raised about some of the positions advanced. Some inconsistency is apparent. Though matching persons to tasks on the basis of personality characteristics, for example, is a plausible aim, the evidence that different types of achievement require different values and styles is missing. Likewise, when McClelland assumes that a person's values, motives, and sensitivities are so stable that they "lead him to behave in certain ways whatever the situation," he appears to pay too little respect to the adaptations most people make readily in going from one role to another.

This yeasty contribution to thinking and research merits the attention of psychologists and sociologists. The first and last chapters have much to say to all others concerned with improving education. The committee members offer no definitive answer, but this is a token of their wisdom; the problem of talent is broad, and our ignorance of basic facts is great.

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University of Illinois

Zhurnal Mikrobiologii, Epidemiologii i Immunobiologii. vol. 28, No. 1–3. *Min. zdravookhranenia.* Moscow, S.S.S.R. English translation. D. J. Bauer, scientific translation Ed. Published on the initiative and with the financial support of the National Institutes of Health, Public Health Service, U.S. Department of Health, Education, and Welfare. Pergamon Press, London and New York, 1957.

Everybody who knows Russian scientific writing will be worried about the attempt to give a complete, word-by-word English translation of a Russian *Zhurnal.* It is not enough to know the two languages. It is necessary to have a thorough knowledge of the different fields of science, the special terminology of both languages, and, furthermore, the Russian scientific slang.

The scientific value of the translation will be determined by the exactness of the translation. Comparison of the original Russian text with the English translation will show how accurate the latter is in this most important respect.

The articles of the *Zhurnal* vary greatly in their difficulty for the translator. Easiest to translate are the short technical papers; most difficult are the long "general" articles and those saturated with Marxist philosophy.

Many of the technical papers are surprisingly well translated; among these are the articles by Nabokov (No. 1, page 19), Varfolomeeva (No. 1, page 38), Markova (No. 2, page 185), Miasnikov (No. 2, page 270), Zherikova (No. 3, page 329), and many others. Unfortunately not all the translators had the knowledge necessary to produce perfect translations. The translations contain many errors, some of them grave, which completely distort the original text. Table 1 shows some of these errors.

As Table 1 shows, errors are caused by lack of knowledge in the special field of science under discussion or by misunderstanding of the Russian text and terminology. Some improvement can be noted: the third issue contains fewer errors than the first. There are practically no printing errors.

The technical papers reveal, to the unprepared Westerner, the incredibly unsanitary and poor living conditions in rural Soviet Russia. Epidemics of a type for generations unknown in the West ravage the people of Soviet *kolkhozes.* The cadavers of dead animals are thrown into gardens and the dogs tear them apart (No. 2, page 247). To prevent their freezing, young animals are kept in the living quarters (No. 2, page 248), or at least this was the case until an anthrax epidemic swept through the population. Some *kolkhoz* workers stay for long hours with bare feet in mud contaminated with urine and feces of swine (No. 2, page 241). These farms have very little water, and what water there is, is stored in barrels embedded in earth. From these barrels water is used both for pigs and for people. On the farms discussed in these papers, the small pig pond was extensively used by the inhabitants for bathing (No. 2, page 242). Such conditions caused the development of a great deal of swine leptospirosis among the population of these *kolkhozes.* The reader is told that during these calamities the population receives scientific help from government agencies. The epidemics, the course of diagnosis, and the preventive measures taken are well described in the translations and provide the most rewarding reading in the volume; these are not pages from a text-

book of bacteriology but are from the book of life itself.

The use of slang in Russian scientific papers caused the translators a great deal of difficulty. The slang words are mostly those used to shorten an expression, or they are technical terms lacking in Russian and taken from some foreign language and then used in Russianized form. These expressions, abundant in the era after the Russian revolution, have appeared less often in more recent years. Let us mention only a few of them: *massovost* (No. 2, page 205), for "the absolute number"; *passirovanie* (No. 2, page 171) for "passage cultures"; *puzyrchatka* (No. 1, page 34) for cystitis. It is doubtful that a translator can find the right expression in English for these words.

Among the articles published in the *Zhurnal* it is necessary to point out some which, in content and treatment of subject, are of a type unknown in the West. We are familiar with the reviews in our periodicals giving a summary of achievements in one or another field of science, giving also more or less complete bibliographies. Quite different are the Russian "general" articles. They restate

Table 1. Examples of errors in translation which distort the meaning of the Russian text.

Russian version	Published translation	Correct translation	References: Issue No. and page of the *Zhurnal* (page No. of English text in parentheses)
pri kotorykh otmechaetsia tak nazyvaemoe zdorovoe zarazonositelstvo	with the exception of those few infections distinguished by the title subclinical	which are known as so-called healthy disease carriers	No. 1, p. 8 (5)
smena patogennym parazitom svoego biologicheskogo hoziaina vo vremeni i prostranstve protekaet pri razlichnykh infekciakh razlichno	the changes effected by the pathogenic parasite in its biological host vary according to the infection	in different infections the pathogenic parasite changes his biologic host in time and space in different ways	No. 1, p. 8 (5)
iz semeistva iksodovykh	Ixodisdae	[New terminology?] Ixodinae, Ixodidae	No. 1, p. 10 (7)
Shotmiuller	Schott-Müller	Schottmüller	No. 1, p. 11 (9)
pribavlenie polnogo antigena	addition of the pure antigen	addition of the complete antigen	No. 1, p. 13 (11)
vsasyvanie sostavnykh chastei pischevykh veschestv v verknikh otdelakh (tolstogo kishechnika)	absorption of the products of food substances digested higher up	absorption of food components in the upper part (of the large intestine)	No. 1, p. 13 (11)
sluchai disenteriinykh poliartritov	dysenteric polyarteritis	dysenteric polyarthritis	No. 1, p. 14 (12)
prosteishie i gelminty	commoner helminths	protozoa and helminths	No. 1, p. 14 (12)
posle perenesennoi dizenterii	after being a carrier of the disease	after recovery from dysentery	No. 1, p. 15 (12)
samymi raznoobraznymi toksinami	by the same types of toxin	by the most different toxins	No. 1, p. 15 (13)
v podkozhnoi kletchatke	superficial fascia	subcutaneous tissue	No. 1, p. 127 (129)
bez gigantskikh kletok	without macrocytes	without giant cells	No. 1, p. 127 (129)
posev nuzhno proizvodit ne ochen gusto	plating must not be carried out too quickly	plating should be carried out not too densely	No. 2, p. 21 (182)
iz probirochnykh metodov titrovania skarlatinoznogo toksina	one animal test method of titrating scarlatinal toxin	one in vitro method of titrating scarlet fever toxin	No. 2, p. 26 (187)
toksinov-po 1 ml v prostykh probirkakh	toxins—1 ml unmixed in a series of tubes	toxins—1 ml in the ordinary test tubes	No. 2, p. 29 (189)
vnutrikletochnoe parazitirovanie	intracellular infection	intracellular parasitism	No. 2, p. 47 (207)
Gall (1948) schitaet chto vvedenie syvorotki ranee privitym posle ranenia podavliaet vyrabotku organizmom antitoksina	Gall (1948) considered that the giving of antiserum to those previously inoculated potentiates the elaboration of toxoid	Gall (1948) thinks that giving of serum to the injured who have been previously inoculated depresses the production of antitoxin by the organism	No. 2, p. 50 (210)
u oboikh krolikov uvelichenie titra imelo mesto tolko na 5-e sutki	the rise in titre in both rabbits lasted only to the fifth day	the rise in titre in both rabbits occurred only on the fifth day	No. 2, p. 52 (211)
v predelakh pervogo desiatka edenitc v 1 ml	concentrations of less than one tenth of a unit per ml	within the limits of the first ten units per ml	No. 2, p. 72 (229)
epidemii raka	influenza epidemics	epidemics of cancer	No. 3, p. 5 (315)
ishodia iz rasshiritelnogo tolkovania simbioza	basing his ideas on our increased knowledge of symbiosis	on the basis of a broader concept of symbiosis	No. 3, p. 6 (316)
v prosvete pischevaritelnoi trubki	in the lumen of the oesophagus	in the lumen of the gastrointestinal tract	No. 3, p. 9 (319)
rezko otlichaiutsia odna ot drugoi po svoei epizootologii	are rarely distinguished from one another in their epizootology	differ sharply from one another in their epizootology	No. 3, p. 13 (323)

mostly well-known, often elementary, facts, largely known even outside the circle of specialists. The authors build on these data long reviews, with wide speculation and generalization in many directions. Such articles would never be accepted by a Western periodical, but the editors of the *Zhurnal,* after printing such an article by Diadichev in three issues ("Contributions to the study of the epidemic process"), ask for more works of this kind (No. 3, page 317). In none of these three articles does Diadichev give a single note of bibliography. The translation of such writing is distasteful to the translator, and many mistakes originate in such translations.

Westerners should bear in mind that the official philosophy to which every Russian scientist is supposed to adhere is that of dialectical materialism—that is, Marxism. With this official doctrine is connected, in Russia, worship of the physiologist Pavlov. This is chiefly because of his works and teachings about the function of the brain and nervous system. Long articles and discussions on these subjects are popular in the Russian periodicals. Such sections of Russian works will seem rather tedious and unreliable to the Western reader. Let us take as an example the article of Gordienko (No. 1, page 138). His "few words" are as long as five pages of small print and start with the quotation: "There must be a painstaking accumulation of facts and its correct understanding on the basis of theory of dialectical thinking." Translation of these articles is difficult because of lack of adequate expressions in English. For 40 years the Russians have hammered on this philosophy and produced a language unknown in the West.

The inclination of Russians to overestimate the achievements in science of their men who have done some experimentation or writing has been even more accentuated in the English translation. The Russians give a relatively poor 3½-by-2½-inch picture of Grigoriev; the picture of him in the English version is 5½ by 4 inches—large and very expressive. The Russian *Zhurnal* is printed on cheap, grayish paper; the English edition is on heavy, glossy paper.

E. Darzins

Anoka State Hospital,
Anoka, Minnesota

The Limits of Mankind. R. A. Piddington. Wright, Bristol, England, 1956. vi + 153 pp. $2.60.

"The overshadowing menace of our time is not the Hydrogen Bomb or War or Communism, but the fact that makes all those three spectres loom so large—namely, the increase of mankind by at least thirty millions annually, and chiefly where the standard of living is so low that all the technical skill of the West, if devoted to the task, could not catch up with the enormous additional demands which that increase brings every year." So writes the author of this little book with big impact.

For too long, in discussions of human population, food has been given first attention. It is time, says the author, to look further. This he proceeds to do in an impressive exposition which deserves to be read by every thoughful citizen. I would question, however, whether the food problem for the masses of living human beings around the world has, in fact, been solved. Even now the cost of food steadily rises in productive, rich America, and so recent an author as Cole [*Sci. American* **198,** 92 (1952)] writes that, as one who would like to live on a meat diet, he cannot see very much to be optimistic about for the future.

Nevertheless, for the sake of Piddington's thesis, and in order to assure some much-needed attention to other problems, let us consider some of the author's further points.

For one thing, a minimum of habitable space, as implied also by Sears [*Science* **127,** 9 (1958)], is essential to satisfactory living. Will the purpose of the human race be better served by 5000 million human beings than by 2500 million?

If man persists in destroying the balance of nature, thinks the author, he will contrive his own doom "as surely as if he let loose unlimited radio-activity in both hemispheres." There does seem to be much truth in the statement that "under the dominion of *Homo sapiens,* the world has steadily become denuded of bulky slow-breeding species and overrun by hordes of fantastically prolific vermin and insects."

Close-set, crowded populations facilitate infection. Also, as the epidemic diseases are brought under control, chronic ills seem to be increasing.

The expansion of intellectual civilization that has occurred in the past two centuries bids fair to be less useful than it should be, simply through being overlarge. The British Museum library, with 6 million books, now occupies some 73 of its 75 miles of shelving, and space remains for only 18 months of intake!

"Travel is a universal passion that grips like a drug" asserts our author, and "many unique treasures are being spoiled or destroyed at an accelerated tempo by the hands and feet of the ever-increasing pilgrimage that surges round or through them." We in the United States can see the deterioration proceeding before our very eyes in our own national parks.

"At present, each voter in Britain, in an electorate of 20,000,000, has a one-twenty-millionth share in the government of others . . . but only a twenty-millionth share in the government of himself . . . ," so he is a good deal more conscious of being governed than of governing! Since, in the United States, our population is greater, we are in even worse case; and what shall we say of India and China?

Seemingly, planetary colonization offers little hope for relief. Thirty million persons would have to be exported every year to keep the present population from increasing, and in a few more years the figure would be 60 million.

The author appropriately pays his respects to those who believe that those who feed well do not breed well, that all we have to do to solve our population problems is to build up our industries.

The author's treatment of this difficult subject of population regulation affords a novel approach to some of the things we will face as population continues to increase. It must be conceded that in the absence of effective thought and action, the living conditions of our children will leave much to be desired.

The book has an excellent index. A bibliography would have been helpful.

Walter P. Taylor

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Atlas of the Sky. Vincent de Callataÿ. Translated by Harold Spencer Jones. St. Martin's Press, New York; Macmillan, London, 1958. 157 pp. Illus. $12.50.

Planned for "amateurs who do not have a telescope," the central offering of this atlas is a series of 36 charts with white stars on black background. The charts are designed to appear as much like the real sky as possible. No names or numbers appear on them, but white lines join the brighter stars of a given constellation to help identify its configuration. The first nine charts cover major areas of the celestial sphere; each of the rest pictures a few constellations in detail, including all stars brighter than magnitude 5.5. Each detailed chart is accompanied by one or more maps giving constellation boundaries and designations of the stars and by a listing of objects of interest to the naked-eye observer. With each chart is a short summary of knowledge about a specific topic of stellar astronomy; for example, globular clusters are described along with the chart of Hercules and diffuse nebulae with Orion. At the end is a series of 12 Mount Wilson and Palomar photographs.

The natural charts, although handsome in concept, suffer in two respects.

The broad-area charts do not discriminate brightness; the white dots are all about the same size. While the detailed charts faithfully allow for the brightness of individual stars, the lines joining them fluctuate greatly in intensity: here bold, there detectable only under special illumination. Another difficulty is that the beginning observer, living at a certain latitude, can nowhere find in the atlas specific instructions on where in the sky to look for a given object at the time and date he wants to look. Although the topical summaries are factual and instructive, they occur in random order. Here and there they are blemished by an error of fact or a misleading statement. I cannot agree, for example, that Mizar and Alcor "can be separated only by persons with very keen eyesight." The abbreviated summaries will have fulfilled an important function if, as the author hopes, they "induce beginners to read other works that are more complete and more learned."

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Algeria. The realities. Germaine Tillion. Translated from the French by Ronald Matthews. Knopf, New York, 1958. viii + 115 pp. $2.50.

This concise, clear, devastating account of the impasse in French-Algerian relationships is the type of political essay that informs without overwhelming the reader with detail. Germaine Tillion is an ethnographer who did extensive field work in Algeria in the 1930's, was chief of a Resistance network from 1940 to 1942, spent three years in prison, and returned to Algeria in 1954 to restudy the people of the Aurès Mountains, the scene of her previous ethnological work. The combination of deep feeling and scientific objectivity with which the book is written was primarily generated by her recognition of the marked change for the worse among the rural people of Algeria between 1940 and 1954, in spite of the enormous economic effort that France had made to better their condition.

Miss Tillion cuts straight through the prevailing optimism—symbolized by "Point 4" in the United States—that it will be a relatively simple matter, involving some technical *expertise* and a small amount of easily found capital, to bring the underdeveloped countries up to a "developed" standard. She highlights, in the concrete knowledgeable discussion of one country, the danger that economists have been stressing for some time—that the gap between the early-industrialized and the not-yet-industrialized countries will be steadily widening, despite all the effort made to close it.

No one has stated more unequivocably the problem of what an unindustrialized country needs in the way of immediate, full-scale construction of all of the facilities in which it pays no one to invest —schools, universities, health services, roads—in order to accomplish an immediate across-the-board transformation of the entire social system. After reading this account, no literate person can take any comfort whatsoever in the statistics of number of schools started or roads under way in the undeveloped countries of the world.

The closing section of the book deals with some of the simple political realities which are likely to be forgotten in planning, chief among them being the fact that Algeria today depends, for the merest inadequate subsistence, upon the right of unskilled Algerian laborers to work in France and bring or send their wages home—a completely politically based economy. One sees, simultaneously, Algeria as a model for the world situation in which various orders of benevolently designated activity (United Nations, "Point 4," development schemes of the various metropolitan powers, schemes for loans from the great powers to the small) are involved, and Algeria as a particular situation which must be dealt with in terms of special historical detail. The emphasis is on responsibility and possible courses of action. No time is wasted on recriminations. No time is wasted on a display of erudition. There is not an unnecessary phrase in the book. A reader who knows nothing about North Africa or mid-20th-century technical assistance can get—in a couple of hours—a satisfying grasp of both the ethical and the economic essentials.

MARGARET MEAD
American Museum of Natural History, New York

Introduction to Biostatistics. Huldah Bancroft. Hoeber-Harper, New York, 1957. x + 210 pp. Illus. $5.75.

Quantitative methods continue to replace qualitative evaluation even in medical research. Diagnosis and therapy are increasingly based more on a rigorous biometric analysis of clinical, biochemical, and pharmacological data of numerous cases than on the result of the findings in individual cases. Although the indispensable tools for handling numerous observations on many individuals are the methods of statistical analysis, medical students as well as practicing physicians usually have very little statistical training and thus lack the ability to ascertain the validity of the increasing amounts of statistical inferences they encounter in the medical literature. To fill this vacuum Huldah Bancroft, professor of biostatistics at Tulane University School of Medicine, New Orleans, La., has written a very readable textbook on the use of statistics in medicine, showing how to arrive at, as well as interpret, statistical data.

The book presents the usual course of statistical thinking (though in a very condensed form), with samples drawn from the medical practice. It starts with the frequency distribution and centering constants and goes as far as chi-square tests and correlation analysis. Most useful will be the chapter on quantitative methods of bioassay. However, it is regrettable that the author felt compelled to presuppose no more mathematical knowledge on the part of the reader than high-school algebra, which necessarily restricts her capacity to convey a better understanding of the logical basis of statistical theory, which is based upon concepts of probability. It is to be hoped that the coming generation of physicians will feel high-school algebra inadequate for a full understanding of biological phenomena and will acquire the tools essential for comprehending a universe of enormous variability.

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Actions chimiques et biologiques des radiations. Les peroxydes organiques en radiobiologie. R. Latarjet. Masson, Paris, 1958. 156 pp. Illus. Cloth, F. 3600; paper, F. 2800.

This little book presents a series of papers delivered at a symposium at the Radium Institute in Paris in January 1957. The participants were from France, England, and the Low Countries; their presentations, published in either French or English as originally presented, provoked considerable discussion, which has been admirably integrated and which makes fascinating reading.

There is little doubt that organic peroxides are now accepted as playing a major role in the radiation problem. The symposium participants were not of a mind, however, about what fraction of the role to assign to (i) the formation of peroxide directly in the gene substance, (ii) the formation of peroxides of lipids and other substances which then interact with the genetic components, and (iii) the peroxidation of the cell catalysts involved in maintaining and reproducing the genetic material. They gave no attention to the modification of building blocks about to be incorporated into the genetic system.

One gathers that the adherents of the target hypothesis are in a compromising mood and are willing to extend the borders at least slightly beyond the general understanding of the original con-

ception. Specifically, the papers deal with the peroxides of lipids, cumene, amino acids, nucleic acids, and related compounds; with the inactivation of the transforming substance and of bacteriophages; with genetic effects of radiation-produced peroxides in *Drosophila*; and with the "oxygen effect" as measured by increased radiosensitivity of biological materials.

While, because of its nature and origin, this book omits too much to serve as a useful reference, it will inform those who did not attend the symposium about what was occupying the attention of this active segment of radiation biologists. Those who made major contributions to the symposium and the discussion include R. Latarjet, C. Paquot, M. Durup, J. Durup, J. A. V. Butler, J. Weiss, S. Okada, J. St. L. Philpot, F. H. Sobels, L. H. Gray, D. Maxwell, P. Douzou, M. Ebert, H. Marcovich, C. Vermeil, Tikvah Alper, and M. Haïssinsky.

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Reports

New Property of the Crystalline Style of Crassostrea virginica

During experiments in which oysters were fed cultures of the red-colored alga *Cryptomonas* sp. (*1*), oyster feces were consistently green in color. Oysters sacrificed during feeding experiments revealed (i) that red pigment was distributed in the stomach juice and surrounding tissues and (ii) that green masses of disintegrated *Cryptomonas* cells were wound around the head of the crystalline style and packed in the intestine. Normal-appearing *Cryptomonas* cells were found at the esophageal end of the stomach. Samples of stomach juice taken nearer the style showed few motile cells, most being rounded and less red in color. Neither motile nor red cells were found in the intestine.

To explain the rapid action on the cells it seemed advisable to study (i) the direct effect of low acidity comparable to that found in the stomach and (ii) the effect of the style and its strong amylase (*2*, *3*).

Oysters actively feeding on *Cryptomonas* were dissected quickly, and Beckman electrodes were inserted directly into the juice of the exposed stomachs. The *p*H of the stomach juice ranged between 6.0 and 6.3. The *p*H of styles, obtained by placing freshly removed styles across a one-drop electrode, ranged from 5.8 to 6.0. Yonge (*3*) reported lower *p*H ranges in *Ostrea edulis*—namely, 5.4 to 5.9 for stomach juice and 5.2 to 5.4 for the style. Cultures of *Cryptomonas* as well as those of *Monochrysis* sp. and *Isochrysis* sp. (*4*) were centrifuged and resuspended in sea water adjusted to different *p*H levels with Sørensen phosphate buffer. The lowest *p*H's at which these different cells retained their motility and normal appearance for 12 hours or longer were 5.5, 5.7, and 6.0, respectively. Hence, oyster style or stomach acidity could not alone be responsible for disintegration of *Cryptomonas*.

The effect of styles upon algal cells in vitro was studied by means of the hanging-drop technique. Styles removed from actively pumping oysters were washed twice in sea water buffered at *p*H 6.0. Extracts were made by dissolving three to seven washed styles in 1 to 10 ml of sea water buffered at *p*H 6.0. Algal cells were centrifuged and resuspended in sea water buffered at *p*H 6.0. Approximately 0.75-ml quantities of algal suspensions and style extract, or algal suspensions and one-third to one style, were used in hanging drops. The effect of styles upon algal cells was determined by continuous microscopic observation in over 75 experiments at 19 ± 1.5°C.

Disintegration of *Cryptomonas* cells, in both hanging drops and stomach juice, follows a uniform sequence. The first step involves two to three rapid backward jerking movements followed by loss of motility as a globule is everted from the gullet. Within 1 to 2 minutes the cell becomes round and the red pigment slowly fades until only a green mass of indefinite shape remains. Within 30 minutes after the first step, the green material fades until it is barely perceptible. The limiting membrane of the cell is usually indistinguishable after about 10 to 15 minutes.

In drops containing undissolved styles, *Cryptomonas* swimming near the style disintegrated immediately. As the styles dissolved, the area in which cells disintegrated gradually spread from the style toward the periphery of the drop. Disintegration of all cells occurred in 20 ± 5 minutes. In a few preparations containing small pieces of style, the wave of disintegration stopped short of the periphery of the drop. Shortly (within about 5 minutes) after final dissolution of the style, the motile cells were able to swim in any section of the drop, including the area of the dissolved style, without ill effect. In drops containing style extracts, disintegration occurred in three preparations only. In these instances the extracts were used prior to the complete dissolution of styles, the extract containing small pieces of style.

A similar wave was observed to immobilize *Monochrysis* in 20 ± 5 minutes. *Monochrysis* were also observed to swim back through the region of immobilization in the few instances in which the wave stopped short of the periphery of the drop. No change in pigment or other cell contents was observed in *Monochrysis cells*. In contrast to the other species, *Isochrysis* were able to swim near, and even touch, the style without observable effect for more than 72 hours. All algal species appeared normal in boiled style and buffer controls.

These studies demonstrate a property of the oyster style not heretofore reported—namely, the ability to attack certain algal cells only during, or for a very short period after, the dissolution of the style. The substance responsible for this phenomenon is heat-labile and is thought to be an enzyme. This "enzyme" may be a protease, a lipase, or a more powerful amylase than has been previously reported. Although proteases are reportedly absent and lipases have been infrequently found, it is noted that, of the investigations for lamellibranch style enzymes, only in those of George (*5*) have undissolved styles been used. George studied only fat digestion and found lipase present in styles of several lamellibranchs. Further studies on this enzyme may help explain the cause of the rapidly disintegrating animal forms in lamellibranch stomachs reported by Nelson (*6*) and Mansour (*7*).

The differences in algal "response" to style preparations are noteworthy in view of increased experimentation in pure-culture feeding of various Metazoa. It is known that certain algae are good foods and others poor foods for various developmental stages of animals. The tendency seems to be to interpret this in terms of possible differences in nutritive quality of the foods. Observations reported here indicate the differences may be due to "resistance" to digestion by some of the algae.

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References and Notes

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14 May 1958

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

New Excited State of Chlorophyll

In order to account for the high efficiency of photosynthesis, it has been suggested that chlorophyll has long-lived excited states, in which absorbed light energy can be stored for photochemical action. Until now, the only known state of this kind has been the metastable triplet state. The existence of this state has been experimentally verified only in chlorophyll *b*, where, at low temperatures, a fluorescence band presumably originating in such a state was observed at 860 mμ by Becker and Kasha (*1*).

Livingston (*2*) and Linschitz (*3*) have observed, in chlorophyll *a* and chlorophyll *b* solutions illuminated by a strong flash of light, the appearance of very broad absorption bands which they interpreted as originating in the metastable triplet state.

We now find at low temperatures (−193°C) a new sharp fluorescence band at 720 mμ in *Chlorella* and *Porphyridium cruentum*; a similar band appeared at 715 mμ in concentrated ethanolic solutions of chlorophyll *a*. The occurrence of this band suggests the existence of an excited state of chlorophyll in the cell situated slightly below the well-known fluorescent singlet state. This state seems to belong to an aggregated form of chlorophyll. It could be of importance for the mechanism of photosynthesis.

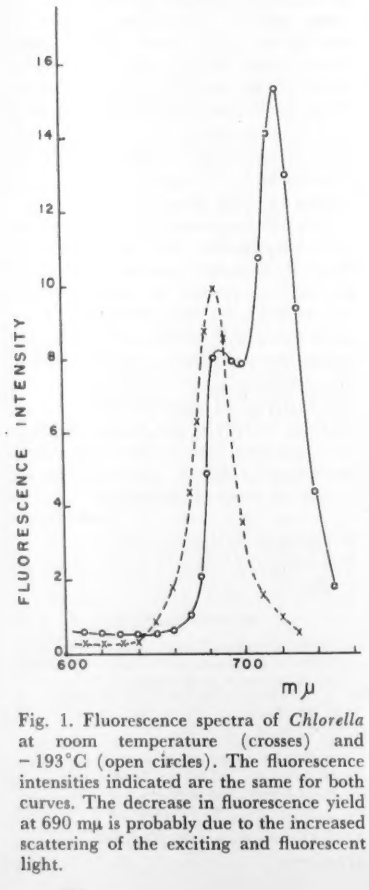

Fig. 1. Fluorescence spectra of *Chlorella* at room temperature (crosses) and −193°C (open circles). The fluorescence intensities indicated are the same for both curves. The decrease in fluorescence yield at 690 mμ is probably due to the increased scattering of the exciting and fluorescent light.

The main fluorescence band of *Chlorella* lies at 685 mμ, with a relatively weak vibrational sub-band at about 740 mμ. Figure 1 shows the new fluorescence band which appears when *Chlorella* is cooled down to liquid-nitrogen temperature. The fluorescence spectra of *Chlorella* cells at room temperatures published by Vermeulen, Wassink, and Reman (*4*) and by Duysens (*5*) suggest the existence of a second fluorescence band on the long-wave side of the main one; perhaps these observations are related to ours. A very strong fluorescence peak at 720 mμ was observed at room temperature in *Porphyridium cruentum* by Duysens (*6*), who attributed this peak to an "unknown pigment" (perhaps chlorophyll *d*). However, Strain (*7*) found no chlorophyll *d* in this species of red algae. Again, this may be the same band as the one we have found at low temperatures. Identification is supported by our observation that, when *Phorphyridium* is cooled to −193°C, the 720-mμ fluorescence band increases more than fivefold in intensity.

Light emission by chloroplast material at low temperature in the region 700 to 900 mμ was described by Tollin and Calvin (*8*), whose observations indicated a life time of several seconds. No spectral analysis of the emitted light was attempted.

Concentrated solutions (10^{-3} to $10^{-2}M$) of chlorophyll *a* (as well as those of chlorophyll *b*) also show new fluorescence bands when cooled to liquid-nitrogen temperature. This phenomenon could not be observed in dilute solutions ($10^{-6}M$); all that happened when such solutions were frozen was that the fluorescence maxima at 670 mμ (chlorophyll *a*) and 660 mμ (chlorophyll *b*) were slightly shifted toward longer wavelengths (680 and 670 mμ, respectively).

Figure 2 shows the intense fluorescence band, with a maximum at 715 mμ, appearing in concentrated ($3 \times 10^{-2}M$) ethanolic solutions of chlorophyll *a*. At this concentration, at −193°C, the "old" band at 690 mμ shows only as a shoulder on the short-wave side of the "new" band. At somewhat lower concentrations, the two bands appear as separate peaks.

Concentrated solutions of chlorophyll *b* show, at −193°C, a new fluorescence band at 645 mμ—that is, on the short-wave side of the "old" band; another new band may exist at 695 mμ. Lavorel (*9*) has described the absorption spectrum of a very concentrated chlorophyll *a* solution in liquid paraffin; in his curve, there is a shoulder, suggestive of a band at 700 mμ, perhaps related to the new fluorescence band.

The importance of high concentration for the appearance of the 715-mμ fluoresence band in vitro suggests that this band may be due to dimers or higher aggregated chlorophyll molecules.

That molecular aggregates do exist in highly concentrated chlorophyll solutions was shown by Rodrigo (*10*). According to his observations, at room temperature, in a $10^{-3}M$ acetone solution of chlorophyll *a*, the average molecular weight of chlorophyll is almost three times the normal one.

After cooling to −193°C, concentrated chlorophyll solutions could conceivably have formed crystalline molecular aggregates. However, when crystalline chlorophyll *a* and *b* (or the corresponding chlorophyllides) prepared according to

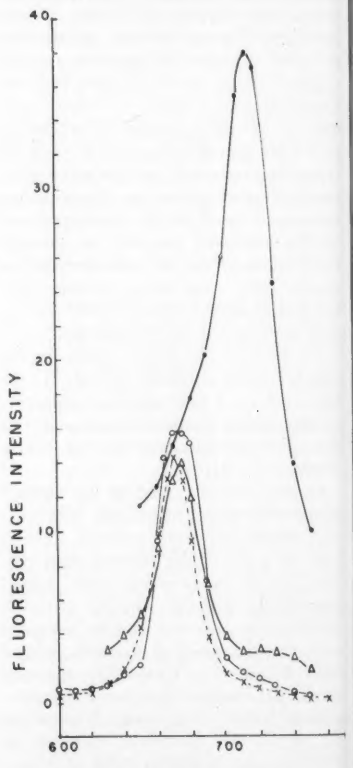

Fig. 2. Fluorescence spectra of concentrated and dilute ethanolic solutions of chlorophyll *a* at room temperature and −193°C: (crosses) spectrum of dilute solution room temperature; (open triangles) spectrum of concentrated solution at room temperature; (open circles) spectrum of dilute solution at −193°C; (solid circles) spectrum of concentrated solution at −193°C. The fluorescence spectra of dilute solutions of chlorophyll *a* do not change radically at low temperature. However, concentrated solutions at −193°C. develop a large new fluorescence band at 715 mμ. At slightly lower concentrations the two fluorescence maxima can be resolved.

Holt and Jacobs (*11*) were examined, no fluorescence bands were found, at either room temperature or at liquid-nitrogen temperature, which could be considered to correspond to the 715 mμ band found for concentrated solutions. (These crystals were described as "non-fluorescent," but we noted a weak fluorescence band at 680 mμ. It cannot belong to the crystals, whose absorption band lies at > 720 mμ; it may have been due to the presence of a small amount of colloidal material, with an absorption band at 670 mμ.)

In the cell, the fluorescence band at 720 mμ could conceivably be due to a new molecular species, such as chlorophyll *d*, having an absorption and a fluoresence band on the long-wavelength side of those of chlorophyll *a* (as suggested in the case of *Porphyridium*). However, alcoholic extracts from *Porphyridium* showed no fluorescence band at 720 mμ, at either $+20°C$ or $-193°C$. This supports the hypothesis that the 720-mμ band is due to an aggregated form of chlorophyll *a*.

Kok (*12*) and Coleman *et al.* (*13*) have observed a "difference" band at 705 mμ in the absorption spectra of dark and illuminated cells of *Chlorella* (and some other algae). This may mean that the 720-mμ fluorescence band is correlated with an absorption band close to this position.

The great increase in intensity of the 715-mμ fluorescence band in vitro (and of the 720-mμ fluorescence band in the cell) at low temperature could be due either to an increase in the relative *concentration* of the aggregates or to an increase in their *yield of fluorescence*. The latter is not impossible if the new fluorescence band originates in a metastable level, which at room temperature is too rapidly used up by photochemical reactions, collision deactivation, and internal conversion, to emit fluorescence. At low temperatures, all these deactivation processes are slowed down. Lifetime determination, and other quantitative studies, should permit a check of this hypothesis.

The new energy level could correspond to a triplet or $n\pi$ level. The new level would lie closer to the singlet $\pi\pi$ excited state in the aggregate than in the monomer.

In vivo, the chlorophyll fluorescence yield increases (according to Franck, French, and Puck, *14*) and the absorption in the neighborhood of 705 mμ decreases (according to Kok, *12*) with incident light intensity, until the saturation of photosynthesis is reached. These changes can be related to changes in the concentration of aggregated chlorophyll in light. When the intensity of the incident light increases, some aggregates may break up into monomers. This would cause a decrease in absorption at 705 mμ and an increase in chlorophyll fluorescence at room temperature (if the monomeric form of chlorophyll is fluorescent at all room temperatures, while the aggregated form only becomes flourescent at low temperatures).

Possibly the drop in photosynthesis on the long-wavelength side of the chlorophyll absorption band (*15*) may be due to increased absorption of light energy by the aggregated form of chlorophyll. The absorption band leading to the new level should be located at about 700 mμ. Because of the strong selective scattering in this region (*16*), it would not be easy to identify. The most careful measurements of absorption spectra of live cells do not exclude the possibility that the red absorption band contains more than one component. To utilize the energy stabilized in the new energy level (aggregated chlorophyll), light of shorter wavelengths may be required—perhaps, to produce a doubly excited state, as suggested by Franck (*17*) (*18*).

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19 May 1958

Immunogenetic Dissection of the T5 Bacteriophage Tail

Studies of the antigenic structure of several bacterial viruses (*1–4*) have led to the recognition of two non-cross-reacting surface antigens, which are designated the head and tail antigens, respectively, according to their apparent localization in the virus particle (*3*). Since the ability to react with neutralizing antibody appears to be an exclusive property of the phage tail (*2, 3*), which contains also the sites of attachment to host cells (*5*), specific neutralization and host adsorption afford tools for studying the structure and function of this virus organelle. The relation between the host-attachment sites and the antigenic sites of the tail has not yet been fully settled, but in some instances the sites show a close genetic association (*6*).

Several lines of evidence (*4, 7*) have suggested that the virus tail itself may be antigenically heterogeneous; however, evidence is yet to be presented that one and the same virus particle can react through different critical sites with two dissimilar neutralizing antibodies. This report is a brief description of experiments (*8*) which supply this kind of evidence for phage T5.

The principal conclusion, that this virus contains at least two distinct antigenic determinants in that portion of the virus particle which is sensitive to neutralizing antibody, rests on the following facts, some of which have been reported previously.

1) Phage T5 stocks form plaques with equal efficiency on *Escherichia coli* strains B and F (smooth derivative of FCb) (*9*).

2) Either of these hosts can adsorb the bulk (over 99 percent) of the plaque formers for both. This fact is crucial to the conclusion.

3) All T5 stocks contain readily isolated host-range mutants, designated BF^-, which adsorb onto and infect strain B but not F (*9*).

4) These mutants cross-react reciprocally with T5 in specific neutralization, but both of the homologous reactions are stronger than the cross reactions (*10*).

5) The cross-reacting antibody can be removed readily from a T5 antiserum (rabbit) by absorption with BF^-, leaving behind a large fraction of antibody (about 50 percent as measured by neutralization of T5 for strain F) which has a striking behavior against phage T5. Like the original serum, it neutralizes the infectivity for strain F in an almost exponential fashion down to 1 percent survivors and beyond; but the infectivity of the same sample for B, instead of decreasing progressively, levels off and remains at about 50 percent, while the infectivity for F vanishes. The leveling off is not due to antibody depletion, since a fresh input of T5 is neutralized just as is the first input.

6) The stable survivors infective for strain B no longer adsorb to F (the adsorption rate constant is less than 0.3 percent of that for untreated T5). They adsorb to B at about half the initial rate. When allowed to grow on B, they produce progeny that are again capable of infecting F. Hence, treatment of T5

with the non-cross-reacting antibody may be said to produce a phenotypic modification of host range: approximately 50 percent of the initial particles, which could adsorb both to B and to F, become incapable of adsorbing to F and resemble BF^- mutants for their very next host interactions. The evidence is thus clear that these serum-induced BF^- phenocopies have reacted with one or more antibody molecules in a region, presumably the tail, which is critical for host interactions. It remains to be determined whether they differ initially, before serum treatment, from the remainder of the virus particles that become inactive for B.

7) The serum-induced BF^- phenocopies are immune to a fresh input of the same absorbed serum, but they are neutralized readily by unabsorbed serum at a comparable concentration. Hence, they contain, in the critical region, unreacted antigenic sites which react specifically with cross-reacting antibody. Topographically, these unreacted sites must be separated from the reacted sites at least by a distance sufficient to allow further antibody attachment.

Thus, at least 50 percent, and probably more, of the B-infective particles in a T5 stock contain at least two spatially separated and serologically distinguishable antigenic sites in the critical region for host interactions. The experiments reveal nothing further as yet about the manner in which these sites are associated in the virus particle; they may or may not prove to reside on separable subunits. Mutation to BF^- leads to the loss of one kind of antigenic determinant not only from the critical region but from the entire antibody-reactive surface of the virus particle. The exclusion from the critical region follows, by definition, from the failure of the non-cross-reacting antibody to neutralize BF^- mutants. The exclusion from the entire reactive surface follows from the inability of BF^- mutants to remove this antibody from a T5 antiserum.

The tight correlation between the host-interacting and the antibody-binding activities both of T5 and of the BF^- mutants suggests a close relation, possibly identity, between the surface structures responsible for these activities in a given virus particle. Further analysis will be needed, however, before this correlation can be interpreted with confidence. Nevertheless, we can now interpret, or approach from a stronger vantage point, such puzzling phenomena as the dependence of the serum-survivor assay on the assay host, the dependence also of the shape of the neutralization curve on the assay host, and the dependence of these host effects on the particular antiserum employed.

Finally, the demonstration of an antibody that can react with critical sites on a virus particle without neutralizing its infectivity for all hosts means that caution must henceforth be exercised in deciding the locus of action of a "non-neutralizing" antibody.

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19 May 1958

Vulcanization with Tetramethylthiuram Disulfide

Three principal hypotheses have been advanced in efforts to explain the efficiency with which rubber is vulcanized by tetramethylthiuram disulfide (TMTD) in the presence of zinc oxide: (i) formation of carbon-to-carbon crosslinks, in analogy with vulcanization by tertiary peroxides (*1, 2*) or as a consequence of radical addition to the rubber (*2, 3*); (ii) "copolymerization" of disulfide biradicals with olefin double bonds (*4, 5*); (iii) oxidation of a mercaptan formed by attack of a disulfide radical derived from TMTD on the hydrocarbon (*6*).

An outline of a fourth mechanism is described in this report (*7*). Only known reactions, or those for which a closely analogous reaction is known, are required. The mechanism involves the same final step as that of Bielstein and Scheele (*6*). The preceding steps are different, being derived from a symmetrical dissociation of the reagent instead of the unsymmetrical dissociation postulated by these authors.

Table 1. Stoichiometric relations in TMTD vulcanization.

Ratio	Predicted	Found	Reference
$R_2NCS_2^-$ formed/ TMTD taken	4/3	1.32	(*15*)
S combined/ crosslinks	2/1	1.9	(*16*)
S combined/ TMTD taken	2/3	0.61	(*13*)
ZnO required/ TMTD taken	1/1	1.1 –1.2	(*17*)
H_2O formed/ TMTD taken	1/3	0.33–0.50	(*18*)
Crosslinks formed/ TMTD taken	1/3	0.26 0.28	(*16, 19*) (*20*)

The reaction occurs in three stages. The first is a radical reaction of TMTD with the olefin:

Initiation:

$$R_2NCS_2S_2CNR_2 \rightleftharpoons 2R_2NCS_2 \quad (1)$$

Chain carrying:

$$R_2NCS_2\cdot + R'H \rightarrow R_2NCS_2H + R'\cdot \quad (2)$$

$$R'\cdot + R_2NCS_2S_2CNR_2 \rightarrow R'S_2CNR_2 + R_2NCS_2\cdot \quad (3)$$

where R'H is rubber hydrocarbon and R is methyl.

Evidence for free radical activity of TMTD exists in its effects on vinyl polymerization (*8*). The stoichiometry of reactions 1 to 3 follows directly from the experiments of Moore (*9*) with benzothiazyl disulfide. (An alternative set of chain-carrying reactions involving addition at the double bonds is not completely excluded by the available evidence, but reactions 2 and 3 are presently preferred on general grounds.)

The second stage is hydrolysis of the dithiocarbamate ester. In this view the hitherto mysterious role of zinc oxide in vulcanization is seen to result simply from the solubility of basic zinc salts in rubber. Although zinc oxide per se does not react directly with the intermediate sulfur compound, we may write the reaction formally as

$$ZnO + R'S_2CNR_2 \rightarrow R'SZnOC(S)NR_2 \quad (4)$$

to illustrate the essential features of this stage: (i) the carbon-sulfur bond of the vulcanizing reagent is broken by hydrolysis and (ii) with a sufficient excess of basic salt, the rubber hydrocarbon-sulfur reaction product is present as mercaptide.

Finally, the mercaptide is oxidized by TMTD (*5, 10*).

$$R'S^- + R_2NCS_2\cdot \rightarrow R'S\cdot + R_2NCS_2^- \quad (5)$$

$$2R'S\cdot \rightarrow R'SSR' \quad (6)$$

As with reaction 4, reaction 5 is a formal representation of the oxidation step. The actual mechanism may involve radical exchange in the presence of base (*11*) rather than the free radical oxidation implied by Eq. 5.

The over-all equation is:

$$2R'H + 3R_2NCS_2S_2CNR_2 + 3ZnO \rightarrow R'SSR' + 2Zn(S_2CNR_2)_2 + Zn(OCSNR_2)_2 + H_2O \quad (7)$$

All of these products except the oxythiocarbamate have been observed; the COS

detected by Craig, Diller, and Rowe (*12*) may be derived from it. Experimentally determined stoichiometric ratios are summarized in Table 1, for comparison with Eq. 7.

No attempt is made at present to specify the structure of the crosslinks formed, which may depend on temperature. The instability of olefinic disulfides at curing temperatures is well known (*13, 14*).

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19. At 150°C. It should be noted that the maximum efficiency of crosslinking will be obtained only under mild conditions. At normal "curing" temperatures (130° to 160°C) in the absence of added fatty acid or zinc soap, TMTD may be wasted in side reactions. The concentration of so called "sulfide" sulfur in a rubber-TMTD-zinc oxide mixture after vulcanization is a direct measure of the side reactions, as is a low ratio of sulfur combined to TMTD taken.
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16 May 1958

Hydrothermal Recrystallization of Molybdenum Trioxide

Whisker-like crystal growth in metals has been the object of several investigations, especially within the past few years (*1*). Not until very recently has whisker growth in an oxide system been reported (*2*).

In this investigation, whisker-like crystals were grown in the system MoO_3–SiO_2 under hydrothermal conditions. Homogeneous MoO_3–SiO_2 solid mixtures were prepared by "flash-drying" a solution of ammonium heptamolybdate in ammonia-stabilized Ludox (*3*). This was accomplished by dropping the solution, a drop at a time, into a platinum crucible that was heated to a dull red.

It was found that whisker growth could be carried out by placing small ampules containing the MoO_3–SiO_2 solid, together with capillary tubes filled with water, directly into a controlled-temperature furnace. A temperature of 375°C, a steam pressure of 5 atm, and a hydrothermal treatment time of 72 hours produced abundant whisker growth from a 3 weight percent MoO_3–97 weight percent SiO_2 substrate.

A photomicrograph of a MoO_3–SiO_2 solid which was subjected to hydrothermal treatment is shown in Fig. 1*A*. An electron micrograph of a sample of these whiskers is shown in Fig. 1*B*. Their size was observed to vary widely: diameters of 5 to 50 μ and lengths up to about 5 mm were typical.

Physical property measurements were not undertaken as a part of this investigation. However, it was qualitatively observed that MoO_3 whiskers could be bent over a large radius of curvature with no apparent permanent deformation. If the bending were continued, whiskers tended to split longitudinally rather than break along the shorter dimension.

Samples of the whiskers were separated from the MoO_3–SiO_2 substrate and subjected to x-ray diffraction, infrared spectrometer, and arc-emission spectrographic analysis. As a result of these analyses, it was concluded that the whiskers consisted of high-purity MoO_3.

In one series of experiments, films of SiO_2 were prepared by grinding flash-dried Ludox silica sol with enough water to form a paste and spreading the resulting paste on platinum slides. Similar films of MoO_3 were prepared by spreading MoO_3–H_2O paste on the slides. In one of these experiments a film of SiO_2, about 1 mm thick and 2 cm long, was laid down in such a way as to cover one half of a slide. On the other half of the slide a MoO_3 film of similar dimensions was laid down. The two films were in contact. The films were rapidly dried in a furnace at 480°C, and the slide supporting the films was subjected to hydrothermal conditions (400°C and 4.85 atm steam pressure) for 96 hours. The slide was then examined with the aid of a microscope. Whiskers were observed over the entire length of the SiO_2 film. No whiskers were observed on the MoO_3 film.

In a similar experiment but with the SiO_2 and MoO_3 films separated by a 2-mm gap, no whiskers were observed on either the SiO_2 or MoO_3 films.

These data indicate that the migration of molybdena in the growth of MoO_3 whiskers occurs via the solid phase rather than by a vapor-phase process. The silica substrate is believed to play a unique part in the molybdena transport and crystal-growth process.

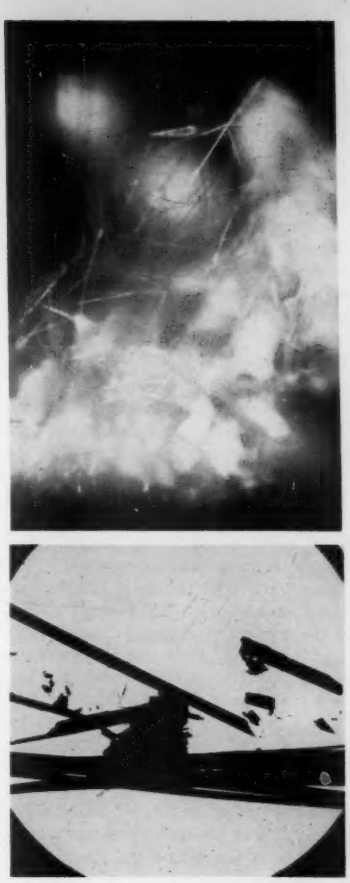

Fig. 1. (Top) Photomicrograph of MoO_3 whiskers grown from a MoO_3–SiO_2 substrate (about × 80). (Bottom) Electron micrograph (2800X) of MoO_3 whiskers (about × 2200).

This is suggested by the fact that whiskers were observed on the silica substrate but not on the molybdena substrate in the film migration study.

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7 May 1958

Effect of Deafferentation on a Conditioned Avoidance Response

Abstract. To determine whether peripheral afferent pathways could be bypassed in the performance of purposive movement, a group of monkeys was trained to avoid shock by flexing a forelimb in response to an auditory stimulus. The dorsal roots of the responding limb were then sectioned. Postoperatively it was found that the affected limb could be reconditioned.

In 1898 Mott and Sherrington (*1*) first reported on the severe impairment of movement which occurs after sectioning the sensory roots innervating the limbs of monkeys. The deficit they described was even greater than the one reported after motor cortex ablations. They concluded that the peripheral afferents, particularly the cutaneous fibres, were necessary for the execution of "the highest level movements."

More recently Twitchell (*2*) investigated in more detail the exact nature of the movement deficit following limb deafferentation. After complete sectioning of dorsal roots C3 through T3, the only movements the animals could perform were flexion and extension of the proximal limb musculature associated with the tonic neck reflex. Unless the tonic neck reflex was abolished by sectioning dorsal roots C1, C2, and C3 bilaterally, these residual movements could be adapted for purposeful, if limited, use, under sufficiently high motivation and only with the accompaniment of vision. He concluded that the role of the peripheral sensory system was to direct the cortical components of movement.

Evidence from conditioning studies, however, indicates that it should be possible to direct limb movements through purely central processes. A recent study by Beck and Doty (*3*) described the conditioning of a flexion response while the responding limb was temporarily paralyzed by crushing its ventral roots. The flaccid paralysis resulting from this procedure should have eliminated the possibility of any "feedback" of sensory impulses during the conditioning procedure, yet, after regeneration of the nerves supplying the limb, the animals gave conditioned flexion responses to a buzzer. This seemed to indicate that the entire conditioning process involved purely central mechanisms.

If this interpretation is correct, then the conditioning procedure should enable central factors to direct the actual performance of conditioned responses. The preliminary study described here (*4*) was designed to test this assumption. This was done by observing the performance of a conditioned response in monkeys after total deafferentation of the responding limb.

Five rhesus monkeys were trained to avoid shock by flexing a limb in response to a buzzer. A large opaque collar, 25.5 by 14.5 in., attached to the chair in which the animals were seated, precluded the use of any visual cues in the learning or performance of the response. Two electrodes used to deliver shock were fastened to the left forelimb, while an elastic tied to the right forelimb was attached at the free end to a microswitch. Upon the flexion of the right forelimb, the elastic pulled the microswitch lever, breaking the circuit and ending the trial. The conditioned stimulus was a buzzer which sounded for 3 seconds prior to the onset of shock. If the animal did not respond, the buzzer and shock continued for 1½ seconds together, unless the trial was terminated by a response during this interval. Thus, a response during the first 3 seconds would result in avoidance of shock, while a response during the next second and a half would result in termination of shock. Two animals were trained at a shock intensity of from 1 to 2 ma, while three were trained at intensities of from 4 to 6 ma.

Table 1. Postoperative data for first and last conditioning sessions. Percentages are calculated on the basis of ratio of avoidance responses to total number of trials per day.

Animal	Shock intensity (ma)	Avoidance responses (%)	
		First day	Last day
1	4–6	29	100
2*	1–2	0	40
3	4–6	0	100
4	1–2	0	80
5†	4–6	100	100

* Monkey No. 2 never fully recovered and died 3 weeks after surgery.
† Monkey No. 5 had 30 percent of the fibers of dorsal root C8 intact.

After the animals had performed to a criterion of 13 avoidance responses in 15 trials on each of two consecutive days, the responding limb of each was deafferented, from dorsal roots C3 through T2. On completion of the experiment, the operative field was reexamined under magnification. One animal in the high-shock group was found to have a few intact C8 fibres. Another animal in the high-shock group was found to have retained a single aberrant fibre, from the caudal region of C2 running into the rostral area of C3. The three remaining animals had complete dorsal root sections running from C3 to T2 inclusive. The first postoperative testing was started after the animal had fully recovered from the procedure, usually within from 5 to 7 days.

The results are presented in Table 1 and Fig. 1. All five monkeys were reconditioned to avoid shock by making a flexion response without the use of

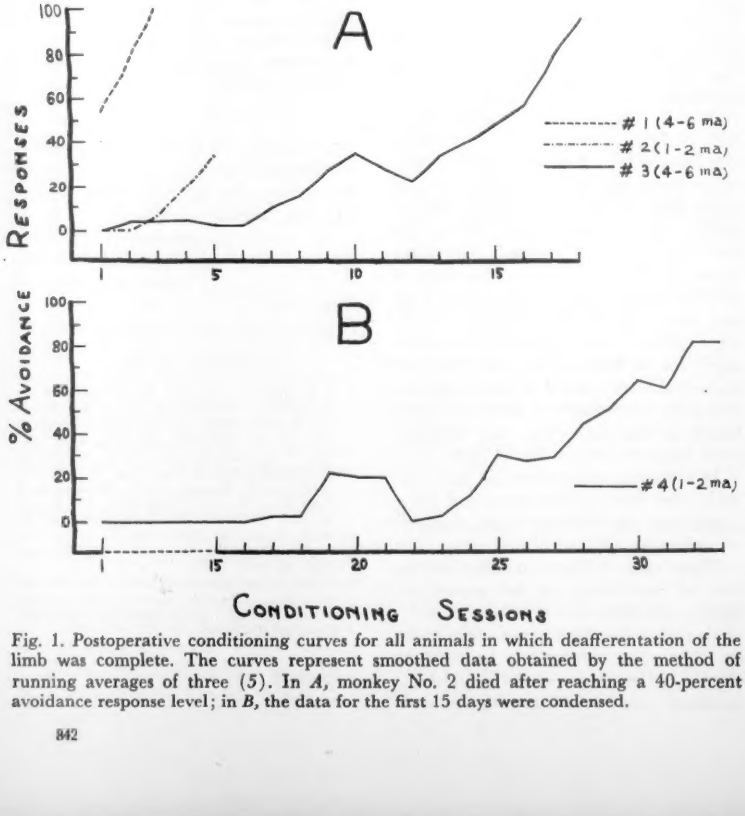

Fig. 1. Postoperative conditioning curves for all animals in which deafferentation of the limb was complete. The curves represent smoothed data obtained by the method of running averages of three (*5*). In *A*, monkey No. 2 died after reaching a 40-percent avoidance response level; in *B*, the data for the first 15 days were condensed.

vision. From these preliminary results it appeared that shock intensity (as measured in milliamperes) was not the determining factor in the postoperative performance. In the free situation the animals behaved exactly as described by both Sherrington and Twitchell. While the monkey was running, the limb was held in a semiflexed position, hand and fingers hanging loosely. The deafferented limb was not used for climbing, and occasional attempts to use the limb for defense always ended in failure. In the conditioning situation, however, the flexion responses were fairly consistent and occurred without obviously associated head and neck movements.

The questions of whether these responses were centrally directed or whether the animals learned to make use of cues provided by intact afferents in other parts of the body are presently being investigated.

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14 July 1958

Restoration of Tryptophan Synthetase Activity in Escherichia coli by Suppressor Mutations

Immunological studies with mutants of *Neurospora crassa* defective in the ability to form the enzyme tryptophan synthetase (TSase) (indole + L serine → L-tryptophan) have shown that certain of these strains form large amounts of a protein, designated CRM, which is immunologically similar to TSase (*1*). One mutant, td_1, allelic by genetic criteria with the other mutant strains (*2*), was found to lack CRM (*1*). On the basis of these observations it was tentatively concluded that CRM represents an altered form of TSase and that one gene controls the formation of TSase and CRM (*3, 4*).

Extensive mutational studies carried out with strain td_1 have shown that this strain does yield tryptophan-independent cultures and that these cultures invariably result from reversions at the td locus rather than suppressor mutations (mutations of different genes reversing the effect of the primary mutation) (*5*). Furthermore, other tests demonstrated that td_1 does not respond to suppressor genes which affect one or more of other mutants lacking TSase (*2*). Since lack of suppressibility appeared to be associated with inability to form CRM in this strain, the possibility was considered that only strains capable of forming a slightly altered TSase are capable of responding to suppressor genes (*3*).

Table 1. Characteristics of the various strains examined.

Strain	Type	Accumulation	Specific activity of TSase	TSase neutralized by 0.02 ml of antiserum
T41	Mutant	Indoleglycerol	0	—
T41-R2	Suppressed mutant	Indoleglycerol	1.5	1.08
T41-R3	Suppressed mutant	Indoleglycerol	1.5	1.38
T41-R4	Suppressed mutant	Indoleglycerol	1.0	1.28
T41-R6	Revertant	None	2.7	1.41
T41-R7	Revertant	None	3.3	1.3
T41-R8	Revertant	None	3.0	1.15
K-12	Wild type	None	2.8	1.24

Mutants of *Escherichia coli* lacking TSase also fall into two categories with respect to CRM formation; one group forms a protein which is immunologically similar to TSase, while the other group does not (*6*). The latter group appears to be comparable to the td_1 type in *Neurospora*. In an effort to examine more thoroughly the question of whether mutants lacking CRM are suppressible, one *Escherichia coli* stock which lacks CRM, strain T-41, was selected for further study (*7*). Cell suspensions of this strain were irradiated with ultraviolet light and plated on a medium lacking tryptophan in a search for suppressor-type mutations. Many small and large trytophan-independent colonies appeared on the plates after 3 days of incubation; several of each type were picked and purified by streaking on a medium lacking tryptophan. Three small- and three large-colony types were selected and examined further in accumulation tests. The three small-colony types accumulated indoleglycerol as does T-41, the mutant they were derived from, while the three large-colony types did not accumulate detectable amounts of any compound related to an intermediate in the tryptophan pathway.

The six selected cultures were also examined in transduction tests (*8*) to determine whether suppression or reversion was responsible for their tryptophan independence. Phage grown on each of the strains listed was used to transduce a cysteine-requiring stock (the cysteine and T-41 genes are closely linked) to cysteine independence, and the treated cells were plated on a medium containing tryptophan. The resulting colonies were then tested for tryptophan dependence. If typtophan-dependent colonies were obtained, the original stock must have carried both the T-41 mutant gene and a suppressor gene. If no mutants were recovered, the original stock probably was a revertant. The three small-colony types yielded typical T-41-like trytophan-dependent colonies in these tests, indicating that suppression was responsible for their ability to grow in the absence of tryptophan. The three large-colony types did not yield mutants, and thus they appear to represent reversions at the T-41 mutant locus. The presence of suppressor genes in the presumed suppressed stocks was confirmed by transducing the suppressor genes from these stocks into strain T-41.

Enzyme and immunological studies were performed with the six cultures and are summarized in Table 1. It can be seen that extracts of all six strains exhibit TSase activity, while the strain they were derived from, T-41, does not. It can also be seen that the TSase formed by the six cultures is normal in the sense that approximately equivalent amounts are neutralized by TSase antiserum. The three suppressed mutants appear to form somewhat less TSase than the revertants and the wild-type strain.

These findings indicate that suppressor mutations can restore the ability to form an enzymatically and antigenically active protein to a mutant which lacks CRM.

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6 May 1958

Occurrence of Substances with Juvenile Hormone Activity in Adrenal Cortex of Vertebrates

No effects of vertebrate hormones upon insect growth have ever been demonstrated (*1*). During the past several years we have examined the effects of hundreds of growth factors including a series of vertebrate hormones (*2*), on the development of insects. Particular care was taken to inject the hormones at critical stages in the insect's life history when a hormonal effect on development would presumably be easiest to detect.

The most startling results were obtained with extracts of beef adrenal cortex (*3*). When such extracts were injected into pupae of the Polyphemus silkworm (*Antheraea polyphemus*), the pupae precociously molted into strange creatures which were intermediate between pupa and adult. These intermediates displayed large patches of pupal cuticle and retained such juvenile characters as pupal antennae and immature genitalia (Fig. 1). Indeed, they were indistinguishable from pupae that were injected with extracts of juvenile hormone prepared from insects (*4*) and from others into which active corpora allata were implanted. The experiments have been repeated several times with the same results. Aqueous extracts of the adrenal cortex mimic in detail the action of the juvenile hormone of insects. To our knowledge this is the first instance of a substance extracted from a vertebrate that has a specific morphogenetic effect on an insect, or indeed, on any invertebrate.

It is somewhat surprising that the first chemical extracted from a vertebrate to influence invertebrate growth should resemble the juvenile hormone, for this molecule appears to have no functional counterpart in the vertebrates. In insects it promotes larval development and prevents maturation. A similar agent is not known for vertebrates.

The active principle in the beef extracts has not yet been isolated, but we do know that it is not identical with any of more than 50 cortical components and their derivatives which we have tested so far. Nor can the effects of the cortical extract be duplicated by any of several hundred hormones, vitamins, metabolites, antimetabolites, and enzymes that have been tested (*1, 5*). In short, we are dealing with what appears to be a unique and specific group of substances with juvenile hormone activity, rather than nonspecific substances such as the numerous unrelated chemicals that activate crustacean chromatophores.

Since the cortical extract is rich in steroids, it is tempting to suggest that the active principle and the juvenile hormone itself are steroids. Such a conclusion is consistent with all that we presently know about the chemistry of the juvenile hormone (*4, 6*). In this connection it is noteworthy that Knowles, Carlisle, and Butler have reported that the ovarian-inhibiting hormone of prawns and bees may be a steroid and that they mention briefly that the effect of this hormone can be copied by administering the synthetic sex hormone, methyltestosterone (*7*). If the juvenile hormone and the ovarian-inhibiting hormone prove indeed to be steroids, then this important class of biologically active compounds assumes a central role in the humoral control of growth in invertebrates as well as vertebrates. Rather than being a recent innovation of the vertebrates, steroid hormones may prove to have a far more ancient lineage. Whether the active principle in the cortical extract is similar chemically to the juvenile hormone or merely acts in a similar way is being investigated. The possibility that the extract turns on the corpora allata of the injected pupae is also being studied.

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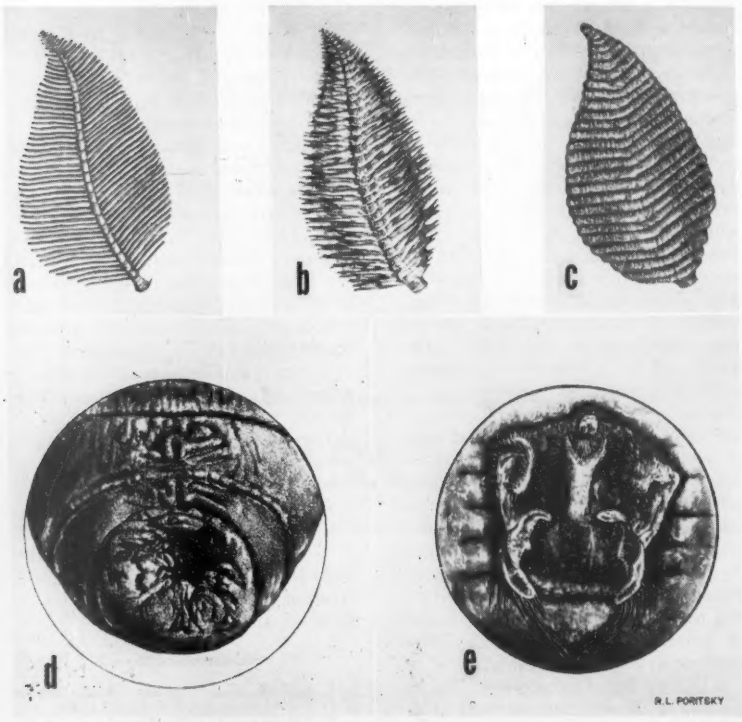

Fig. 1. (*A*) Antenna of an adult Polyphemus moth. (*B*) Antenna of an "intermediate" Polyphemus moth produced by injecting a pupa with adrenal cortical extract prior to initiation of adult development. (*C*) Antenna of a Polyphemus pupa. (*D*) Genitalia of an "intermediate" Polyphemus moth produced by injecting adrenal cortical extract into a pupa prior to initiation of adult development. (*E*) Genitalia of an adult Polyphemus moth.

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1. C. M. Williams, *Harvey Lectures*, Series 47, 126 (1952).
2. This investigation was supported by a grant (H-1887) from the National Heart Institute, U.S. Public Health Service.
3. Aqueous extracts of beef adrenals were generously supplied us by Prof. S. L. Leonard of Cornell University and by Dr. P. Perlman and his associates at the Schering Corp., Bloomfield, N.J. The Schering Corporation also supplied us with many of the crystalline steroids that were tested.
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24 April 1958

Action Spectrum for Triphosphopyridine Nucleotide Reduction by Illuminated Chloroplasts

In the presence of the enzyme, photosynthetic pyridine nucleotide reductase (PPNR), chloroplasts carry out a light-dependent reduction of triphosphopyridine nucleotide (TPN) with a concomitant evolution of oxygen (*1*). The over-all process (Eq. 1) appears to require at least two component systems—namely, a photolytic system for the generation of reducing and oxidizing potential represented by (H) and (O), respectively (Eq. 2), and a system which can utilize the reducing potential formed by the photolysis of water for the reduction of TPN to yield reduced TPN (TPNH) as indicated in Eq. 3. Under these conditions, the oxidizing potential is ultimately released as molecular oxygen.

$$H_2O + TPN^+ \xrightarrow[\text{chloroplasts PPNR}]{\text{light}} TPNH + H^+ + \tfrac{1}{2}\,O_2 \quad (1)$$

$$H_2O \xrightarrow[\text{chloroplasts}]{\text{light}} 2(H) + (O) \quad (2)$$

$$TPN^+ + 2(H) \xrightarrow{\text{PPNR}} TPNH + H^+ \quad (3)$$

The evidence available favors the hypothesis that the reaction depicted by Eq. 2 is the primary photochemical act not only in the photosynthetic reduction of TPN, but also in photosynthesis, the Hill reaction, and photosynthetic phosphorylation. According to this formulation, the action spectrum for the reduction of TPN by illuminated chloroplasts should be identical with that for photosynthesis, the Hill reaction, and photosynthetic phosphorylation. Indeed, the action spectra for the latter three processes have been shown previously to correspond both to one another and to the absorption spectrum of chlorophyll (*2*). In this report (*3*), data are presented which indicate that the action spectrum for the reduction of TPN by illuminated chloroplasts also corresponds to the absorption spectrum of chlorophyll.

The experiments were performed with the high irradiance spectrograph of the U.S. Department of Agriculture at Beltsville, Maryland, as follows: Each reaction mixture contained chloroplasts (*4*) equivalent to 75 μg of chlorophyll, 1 μmole of TPN, 185 μg of partially purified PPNR prepared as described by San Pietro and Lang (*5*) and 265 μmole of tris buffer, *p*H 7.2, in a final volume of 3 ml. The optical density of each reaction mixture at 340 mμ was measured before and after illumination for 10 minutes at room temperature with light of different wavelengths. The increase in optical density calculated from these two measurements serves as a measure of TPN reduction.

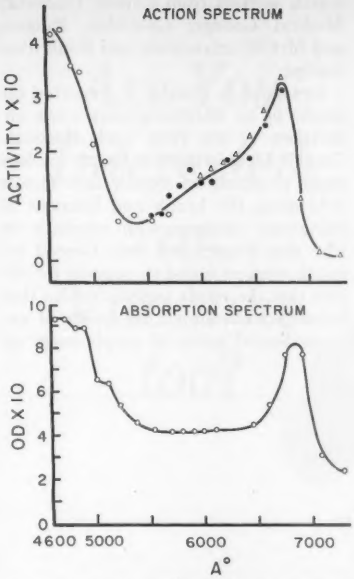

Fig. 1. (Top) Action spectrum for TPN reduction by illuminated chloroplasts. The activity is expressed as micromoles of TPN reduced per average incident micro-Einstein per reaction mixture per 10 minutes. The different symbols signify three separate experiments. (Bottom) Absorption spectrum of the reaction mixture diluted threefold.

All optical density measurements were made with a Beckman spectrophotometer, model DU, with photomultiplier attachment; a complete reaction mixture which was kept in the dark at room temperature was used as a blank. The amount of energy available at each wavelength tested was determined with a thermopile.

The action spectrum for this process is presented in Fig. 1. This action spectrum was obtained by correcting the observed increase in optical density at 340 mμ for the amount of energy available at each wavelength tested (*6*). It is apparent from Fig. 1 that red light and blue light are most effective for the reduction of TPN by illuminated chloroplasts and that green light is least effective. Within the spectral range measured (4630 to 7290 A) the action spectrum for this process closely parallels the absorption of the chloroplasts, as is indicated in the lower portion of Fig. 1, and that of chlorophyll.

It can be calculated that at 6720 A and an incident intensity of 2.88×10^3 erg/cm² sec, the quantum requirement for the reduction of TPN is approximately 16 quanta per molecule of TPN reduced (or atom of oxygen evolved). This value agrees very closely with the value of 17 quanta per atom of oxygen evolved in the Hill reaction, with ferricyanide as the electron acceptor, reported by Lumry *et al.* (*7*).

In conclusion, the action spectrum for the reduction of TPN by illuminated chloroplasts has been shown to resemble closely the absorption spectrum of the chloroplast suspension and the action spectra for the Hill reaction, photosynthesis, and photosynthetic phosphorylation. This finding supports the hypothesis that all four processes require the same primary photochemical act—namely, the photolysis of water.

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3. This report is contribution No. 236 of the McCollum-Pratt Institute. This investigation was supported in part by a research grant (RG-4143 -C3-) from the National Institutes of Health, U.S. Public Health Service.
4. The chloroplasts were prepared as follows: 25 g of spinach were depetioled and ground in a mortar and pestle, in the cold, with about 4 g of sand and 35 ml of 0.05*M* Na_2HPO_4–KH_2PO_4 buffer, *p*H 7, containing 0.4*M* sucrose and 0.01*M* KCl. The homogenate was filtered through cheese cloth and the filtrate was centrifuged for 1 minute at 200*g* in the cold. The supernatant was then centrifuged for 7½ minutes at 2500*g*. The final residue was made up in 13 ml of the 0.05*M* Na_2HPO_4–KH_2PO_4 buffer, *p*H 7, containing 0.4*M* sucrose and 0.01*M* KCl.
5. A. San Pietro and H. M. Lang, *J. Biol. Chem.* 231, 211 (1958).
6. Due to the high absorption of the reaction mixtures used in these experiments, the average incident light intensity for each reaction mixture was used to determine the action spectrum. The average incident light intensity equals
$$\frac{I_0\,[1 - (I/I_0)]}{2.3 \log \text{O.D.}}$$
where I_0 is the incident intensity, I is the intensity of emerging light, and O.D. is the optical density of the reaction mixture.
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14 May 1958

Meetings

Human Ecology

The results of several inquiries into the Hungarian Revolution of 1956 were reported before an interdisciplinary group attending the second seminar on Hungarian Studies, sponsored by the Society for the Investigation of Human Ecology of Forest Hills, N.Y. The meeting was held 6 June at Columbia University, with Adolf A. Berle, Jr., professor of law at Columbia and a director of the society, presiding. Papers were presented by research workers from Cornell University Medical College; Columbia, Rutgers, and McGill universities; and Radio Free Europe.

Lawrence E. Hinkle, Jr., reported the results of an interdisciplinary study undertaken by the New York Hospital–Cornell Medical Center human ecology study program, an inquiry into factors influencing the health and behavior of Hungarian refugees, with emphasis on why they fought and fled. Cornell research workers found no support for the idea that the revolt and the exodus that followed were simply the results of unpremeditated action of people swept up in a wave of mass emotion. "On the contrary," Hinkle said, "those who participated in these events had deep-seated, realistic, and highly personal motives for their actions." This was true of nearly every refugee studied.

Motives for revolt in the Hungarians studied fell into two general categories. The first was a long-standing and insurmountable feeling of personal insecurity. The refugee believed that no matter what he did or how high a position he attained, his family could be ruined at any time by the actions of others or by events beyond his control. The second was a profound sense of frustration. There was a deep conviction, Hinkle said, that in communist Hungary there was no way for the individual to live out his life as he wanted to and in a manner that would satisfy his needs. These motives persisted, even among refugees who knew they were economically better off than they might have been had the precommunist regime continued to govern.

Paul Zinner, of Columbia University, reporting on the political background of the rebellion, said that a massive discontent and, more important, the disintegration of the Communist Party in Hungary made the revolution possible. The party disintegrated visibly over a 3-year period, beginning with 1953. "The party was not a monolithic block of like-minded people coming from the same background, thinking the same thoughts, and liking each other immensely," he said. "The social composition of the party made it less than unified in its purposes and contained the seeds of future conflict that were to help make the revolt possible."

Richard Stephenson, of Rutgers University, presented the results of a sociological study of Hungarian refugees, focusing on evasive tactics that enabled them to function effectively within communist controls. Some Hungarians, he said, capitalized on special technical skills desperately needed by the communist regime, thereby reaping rewards without conforming to party requirements. Some moved from city to city to disrupt bureaucratic files, and others closed out businesses or left professional roles to provide an approved "worker" background for their children. In the matter of completing work norms, the Rutgers study shows it was common practice for the worker at the bench, the foreman, and the works manager to connive and to lie about and disguise actual production rates. Often strategic industrial positions were filled with political functionaries who lacked the technical competence to detect such practices. When evasive tactics were not practical, Hungarians would pursue tabooed practices covertly. They attended church in a parish other than their own and went from the city into villages to have their children baptized. By such measures as

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Pharmacology and Toxicology

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these, Stephenson said, the Hungarians were able to achieve many of their goals within the rigors of communist control and without accepting communism.

Probably the most important factor in the immigrant's success or failure to adjust to a new environment is the position he enjoyed in the old society, reported A. F. Meszaros, psychiatrist from McGill University. "Class status" often determines the immigrant's reasons for leaving his homeland, Meszaros said, and it also colors his ideas of the position he hopes to find in his newly adopted country. Meszaros reported on a study of 64 Hungarian refugees, 44 men and 20 women, drawn from middle and worker classes. Workers were a favored group in Hungary, the study reveals, while the middle class occupied only a marginal or "tolerated" position and received very few benefits from the communist sociopolitical system. Because they lived under a system of supervision and suspicion, because their livelihood often depended on the whims of party bosses and their every movement was controlled, members of the middle class as a group held an attitude of subdued hostility to the regime. The worker, to whom communism promises most, viewed the regime with mixed feelings. His job continuity and security were assured, and he was encouraged to associate with members of his own class. But he could not change jobs, and his share of material goods remained small because his income remained at a controlled low level. Meszaros believes that the Hungarian worker immigrant, to adjust successfully in North America, must sacrifice his ideas of job security and social prestige, which were automatic under communism, for the greater independence of job mobility and the opportunities to acquire material goods previously denied him. These new attitudes will represent a complete reversal of values for him and will temporarily increase the difficulty of successful adjustment. Adjustment for the middle-class immigrant is not so difficult, Meszaros maintains, because the North American value system does not differ fundamentally from his own value system.

In other papers presented at the seminar, Alexander Dallin, of Columiba University, discussed the "Uniqueness of the rebellion," and Edmund O. Stillman, of Radio Free Europe, discussed interclass attitudes in Hungary, especially as they applied to the relocated agricultural proletariat. Bela C. Maday, executive secretary of the Coordinated Hungarian Relief Association, told of the problems of immigrant Hungarians' adapting to life in the United States.

The society's interest in the Hungarian uprising began when the influx of thousands of refugees into this country created an unprecedented opportunity to study the effects of sudden environmen-

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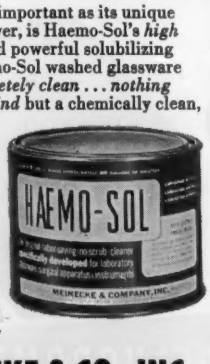

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tal change on the health and attitudes of a large immigrant population. The first seminar was held in Forest Hills, N.Y., a year ago; it brought together representatives of various agencies to exchange views on Hungarian immigration, discuss preliminary findings, and outline plans for coordinating further research.

At the conclusion of the second seminar, preliminary plans were announced for integrating data from all Hungarian studies and making these available for future research.

The society has published the seminar proceedings, including full texts of the papers presented. Copies may be obtained by writing to the Executive Secretary, Society for the Investigation of Human Ecology, Forest Hills 75, N.Y.

JAMES L. MONROE
Society for the Investigation of Human Ecology, Forest Hills, New York

Spectroscopy

The tenth annual Symposium on Spectroscopy of the American Association of Spectrographers is to be held at the Conrad Hilton Hotel in Chicago, 1–4 June 1959. Original papers of emission, x-ray, visible, ultraviolet, near-infrared, and Raman spectrometry and in flame photometry are invited. The meeting will also feature an instrument exhibit by leading manufacturers in the field of spectroscopy. Authors are requested to submit titles *before 1 January 1959* to the program chairman, G. W. Bailey, Borg-Warner Research Center, Des Plaines, Ill.

Forthcoming Events

November

6–7. Lead Hygiene Conf., Chicago, Ill. (M. Bowditch, Lead Industries Assoc., 60 E. 42 St., New York, 17.)

6–7. Nuclear Science, 5th annual, San Mateo, Calif. (H. Pratt, IRE, 1 E. 79 St., New York 21.)

6–8. Geochemical Soc., St. Louis, Mo. (K. B. Krauskopf, Stanford Univ., Geology Dept., Stanford, Calif.)

6–8. Geological Soc. of America, St. Louis, Mo. (H. R. Aldrich, 419 W. 117 St., New York 27.)

6–8. Gerontological Soc., 11th annual scientific meeting, Philadelphia, Pa. (N. W. Shock, Baltimore City Hospitals, Baltimore 24, Md.)

6–8. Paleontological Soc., St. Louis, Mo. (Miss K. V. W. Palmer, 109 Dearborn Pl., Ithaca, New York.)

6–8. Society of Economic Geologists, St. Louis, Mo. (H. M. Bannerman, U.S. Geological Survey, Washington 25)

8. Society for the Scientific Study of Sex, 1st annual, New York, N.Y. (R. V. Sherwin, 1 E. 42 St., New York 17.)

10–12. American Petroleum Inst., 38th annual, Chicago, Ill. (API, 50 W. 50 St., New York 20.)

10–12. Physics and Medicine of the At-

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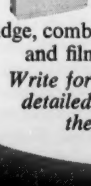

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mosphere and Space, intern. conf. (by invitation), San Antonio, Tex. (Southwest Research Center, 331 Gunter Bldg., San Antonio.)

10–13. American Dental Assoc., Dallas, Tex. (H. Hillenbrand, 222 E. Superior St., Chicago, Ill.)

12–14. Society for Experimental Stress Analysis, annual, Albany, N.Y. (W. W. Murray, P.O. Box 168, Central Square Sta., Cambridge 39, Mass.)

12–15. Society of Naval Architects and Marine Engineers, 66th annual, New York, N.Y. (W. N. Landers, SNAME, 74 Trinity Pl., New York 6.)

16–21. Radiological Soc. of North America, Chicago, Ill. (D. S. Childs, 713 E. Genesee St., Syracuse, N.Y.)

16–23. Scientific Information, intern. conf., Washington, D.C. (Mrs. M. Sheppard, Intern. Conf. on Scientific Information, Natl. Acad. of Sciences–Natl. Research Council, 2101 Constitution Ave., Washington 25.)

17–19. Association of Military Surgeons of the U.S., Washington, D.C. (R. E. Bitner, Suite 718, New Medical Bldg., 1726 Eye St., NW, Washington 6.)

17–20. Conference on Magnetism and Magnetic Materials, Philadelphia, Pa. (H. B. Callen, Dept. of Physics, Univ. of Pennsylvania, Philadelphia.)

17–22. Radiological Soc. of North America, Chicago, Ill. (D. S. Childs, Sr., 713 E. Genesee St., Syracuse 2, N.Y.)

18–20. Air Pollution, 1st natl. conf., Washington, D.C. (Dept. of Health, Education, and Welfare, U.S. Public Health Service, Washington 25.)

18–20. Standards, 9th natl. conf., New York, N.Y. (American Standards Assoc., 70 E. 45 St., New York, N.Y.)

18–21. Weather Radar Conf., 7th, Miami Beach, Fla. (K. C. Spengler, American Meterological Soc., 3 Joy St., Boston 8, Mass.)

18–22. Pan-American Dental Cong., Mexico City, Mexico. (Association Dental Mexicana, Sinaloa 9, Mexico 7, DF, Mexico.)

19–21. Electrical Techniques in Medicine and Biology, 11th annual conf., Minneapolis, Minn. (O. H. Schmitt, Univ. of Minnesota, Minneapolis.)

20–22. Acoustical Soc. of America, 56th meeting, Chicago, Ill. (K. Kramer, 3839 Grand Ave., Western Springs, Ill.)

20–22. American College of Cardiology, New Orleans, La. (P. Reichert, Empire State Bldg., New York 1.)

20–22. International Symp. on Tuberculosis, Philadelphia, Pa. (M. J. Schwartz, Deborah Sanatorium & Hospital, 642 Widener Bldg., Philadelphia 7.)

20–23. American Anthropological Assoc., Washington, D.C. (W. S. Godfrey, Jr., APA Logan Museum, Beloit College, Beloit, Wisc.)

20–23. European Confederation of Agriculture, Vienna, Austria. (M. H. Abegg, Confédération Européenne Agriculture, Brougg (Argovie), Switzerland.)

21–22. American Soc. of Animal Production, annual, Chicago, Ill. (H. H. Stonaker, Animal Husbandry Dept., Colorado State Univ., Fort Collins, Col.)

24–26. Fluid Dynamics, division of American Physical Soc., San Diego, Calif. (R. J. Emrich, Dept. of Physics, Lehigh Univ., Bethlehem, Pa.)

24–26. Mechanisation of Thought Processes, symp., Teddington, Middlesex, England. (The Secretary, Natl. Physical Lab., Teddington, Middlesex.)

24–6. Plant Specialists, 4th Latin American conf., Santiago, Chile. (R. Cortazar, Departmento de Investigaciones Agricolas, Ministerio de Agricultura Casilla 4088, Santiago, Chile.)

27–29. Central Assoc. of Science and Mathematics Teachers, 58th annual, Indianapolis, Ind. (N. G. Sprague, Indianapolis Public Schools, 1644 Roosevelt Ave., Indianapolis 18).

(See issue of 19 September for comprehensive list)

Letters

Blood-Group Nomenclature

The correspondence regarding blood-group nomenclature published in the 23 May issue of *Science* [**127**, 1255 (1958)] calls for amplification and clarification, so that readers may not be misled.

The original Rh factor was discovered by Karl Landsteiner and Alexander S. Wiener in 1937. This blood factor is now designated $\mathbf{Rh_0}$. When the related blood factor **rh′** was discovered by Wiener in

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1940, he pointed out that three possibilities had to be considered regarding the simultaneous heredity of **Rh_0** and **rh′**.

1) Distinct genes determining the respective blood factors **Rh_0** and **rh′** could be postulated, located in different chromosomes (heredity with independent assortment).

2) Distinct gene loci for **Rh_0** and **rh′** might exist, located within the same pair of chromosomes (linkage with crossing over).

3) Heredity might depend upon a series of multiple allelic genes. When studies on the distribution of the Rh factors in the general population as well as family data showed the hypothesis of separate gene loci for **Rh_0** and **rh′** to be incorrect, Wiener discarded the first two possibilities and adopted the theory of multiple allelic genes.

In 1944, Fisher revived and elaborated the linkage theory. The present choice, therefore, lies not between a theory of Wiener and a theory of Fisher but, instead, between two hypotheses both originally elaborated by Wiener; one of these (the linkage hypothesis) he disproved and discarded, but this has now been taken up by those using the C-D-E notations, while the other hypothesis (multiple allelic genes) is supported by the evidence accumulated by Wiener and others from family and population studies. In the absence of evidence of crossing over, some C-D-E workers have modified the theory to one of complete linkage. Since completely linked genes operate as a unit, this reduces to the multiple allele theory, so the choice then lies between two different ways of describing the multiple allele theory originally advanced by Wiener.

The basis on which the nomenclature question rests, however, is not genetic but serologic. It is significant that the original Rh-Hr nomenclature was devised by the discoverers of the Rh-Hr types and their heredity. As Landsteiner and Wiener have pointed out, antigens can give rise to multiple corresponding antibodies. The properties of the agglutinogen molecule which are responsible for the specific combination of an antigen with its corresponding antibodies are known as blood factors, so that every agglutinogen is characterized by multiple blood factors. Thus, it is essential to distinguish clearly between agglutinogens and their serologic attributes, the blood factors. Therefore, in Wiener's Rh-Hr nomenclature, a different type face is used for genes (printed in italics), agglutinogens and blood types (printed in regular type), and antibodies and their corresponding blood factors (printed in bold-face type). For example, as is shown in Table 1, gene *r* gives rise to the agglutinogen rh, which is characterized by the blood factors **hr′**, **hr″**, **hr**, and **Hr_0**; and so on throughout the table. For simplicity, the **Rh_0** variants have been omitted from the table, as well as other intermediate agglutinogens, and despite this the table lists a total of 17 **Rh**-Hr allelic genes and 13 Rh-**Hr** antisera of different specificities. It will be seen that the number of blood factors characterizing an Rh-Hr agglutinogen may range from two to seven, if the reactions of these 13 antisera are taken into account.

In contrast, the originator of the C-D-E notations, while famous for his contributions to biometrics, is not an immunologist and has never done a blood grouping test in his life. His concept of the Rh-Hr types is metaphysical in nature, and embodies the following premises, neither of which is correct.

1) To each agglutinogen there corresponds but a single specific antibody. Thus, no distinction is considered necessary between agglutinogens and blood factors. Corresponding to an agglutinogen or blood factor **X** there is assumed to exist but a single antibody, anti-**X**, and any antigen which reacts with anti-**X** is considered to possess the agglutinogen X.

2) If an agglutinogen X is known to exist, then any blood that lacks **X** always has in its place a contrasting agglutinogen x.

These two premises were used by Fisher to draw up the simple scheme of the Rh-Hr types shown in Table 2. This scheme has gained wide popularity and is quoted in most recent textbooks on hematology. The obvious reason for its popularity is its simplicity. However, the scheme is unrealistic, and those who use the C-D-E notations have exhibited a tendency to force their findings to fit the scheme. For example, they have reported the discovery of antibodies of specificity anti-d, but these reports could not be confirmed and were evidently based entirely on wishful thinking. On the other hand, the existence of other blood factors which do not fit into Fisher's scheme is denied by C-D-E protagonists in the face of overwhelming evidence. An outstanding example is the refusal to acknowledge the existence of the blood factor **C** of the ABO system. The contrast between Tables 1 and 2 is reminiscent of the contrast between the present knowledge regarding chemical elements and the simple metaphysical concept of the ancients of four elements—earth, air, fire, and water. The available data

Table 1. Partial list of Rh-Hr allelic genes, their corresponding agglutinogens, and the reactions with 13 of the available Rh-Hr antisera (Wiener's theory of multiple allelic genes).

Gene	Agglutinogen	Reactions with antisera of specificity												
		Rh_0	**Rh^A**	**rh′**	**rh^{w_1}**	**rh^x**	**rh_1**	**rh″**	**rh^{w_2}**	**hr′**	**hr″**	**hr**	**hr^y**	**Hr_0**
r	rh	−	−	−	−	−	−	−	−	+	+	+	−	+
r^0	rh^v	−	−	−	−	−	−	−	−	+	+	+	+	+
r′	rh′	−	−	+	−	−	+	−	−	−	+	−	−	+
r'^w	rh'^w	−	−	+	+	−	+	−	−	−	+	−	−	+
r″	rh″	−	−	−	−	−	−	+	−	+	−	−	−	+
r^y	rh_y	−	−	+	−	−	−	+	−	−	−	−	−	+
R^0	Rh_0	+	+	−	−	−	−	−	−	+	+	+	−	+
R^{0v}	Rh^v_0	+	+	−	−	−	−	−	−	+	+	+	+	+
$\overline{R^0}$	$\overline{Rh_0}$	+	+	−	−	−	−	−	−	−	−	−	−	−
$\overline{R^{w_1}}$	$\overline{Rh^{w_1}}$	+	+	−	+	−	−	−	−	−	−	−	−	−
R^{0a}	Rh^a_0	+	−	−	−	−	−	−	−	+	+	+	−	+
R^1	Rh_1	+	+	+	−	−	+	−	−	−	+	−	−	+
R^{1w}	Rh^w_1	+	+	+	+	−	+	−	−	−	+	−	−	+
R^{1x}	Rh^x_1	+	+	+	−	+	+	−	−	−	+	−	−	+
R^2	Rh_2	+	+	−	−	−	−	+	−	+	−	−	−	+
R^{2w}	Rh^w_2	+	+	−	−	−	−	+	+	+	−	−	−	+
R^z	Rh_z	+	+	+	−	−	−	+	−	−	−	−	−	+

Table 2. Fisher's scheme of the Rh-Hr types.*

Chromosomes	Agglutinogens or blood factors	Reactions with antisera of specificities					
		C	D	E	c	d	e
cde	cde	−	−	−	+	+	+
Cde	Cde	+	−	−	−	+	+
cDe	cDe	−	+	−	+	−	+
cdE	cdE	−	−	+	+	+	−
CDe	CDe	+	+	−	−	−	+
CdE	CdE	+	−	+	−	+	−
cDE	cDE	−	+	+	+	−	−
CDE	CDE	+	+	+	−	−	−

* As modified from the theory of linkage, previously disproved and discarded by Wiener.

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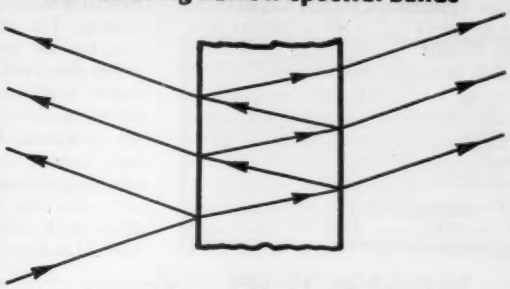

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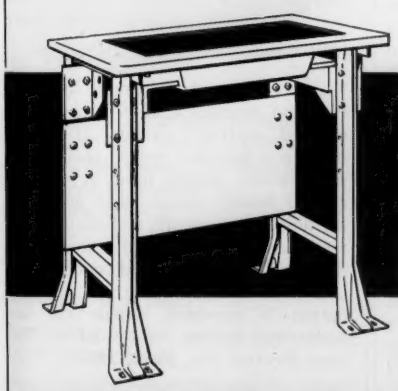

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amply demonstrate that the so-called "triple inheritance" discussed by Race and Sanger in the third edition of their book is fictional, since, as is shown in Table 1, the blood factors are inherited not in three's but in blocks varying from two to seven factors each. Perhaps the C-D-E notations are simpler; but the question involved is not merely one of choice between two designations for the same thing, and workers must decide whether they prefer to do what is simpler or what is correct.

The protest that the report prepared by the American Medical Association committee by four leading scientists is biased, and that the signers of the protest "shall continue to use the C-D-E nomenclature until such time as a properly representative international body arrives at a definite nomenclature" is misleading. The protest fails to mention that for the past decade Wiener has urged that such an international committee be formed, and that before the American Medical Association report was prepared, Fisher and Race were both invited, all expenses paid, to discuss the problem, but they declined.

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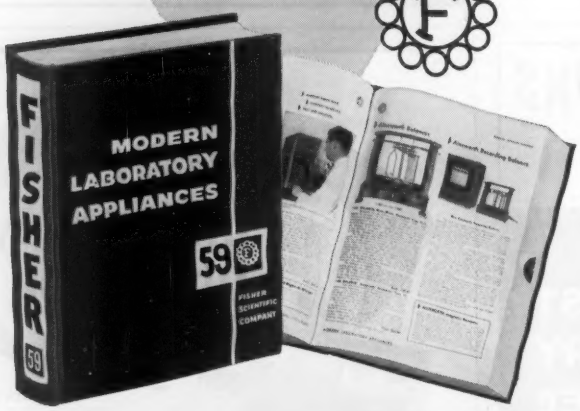

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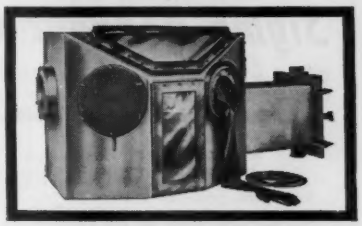

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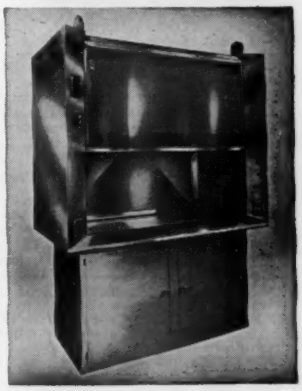

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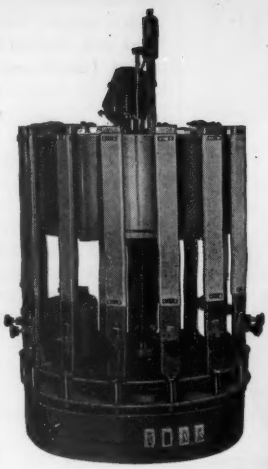

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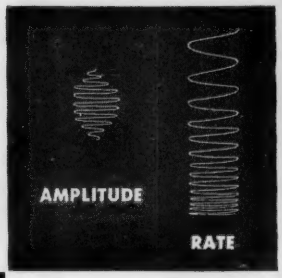

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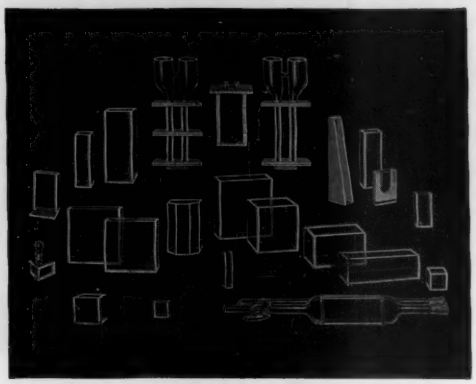

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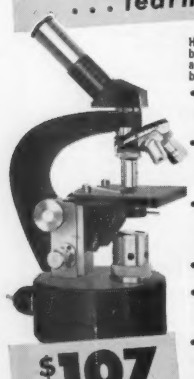

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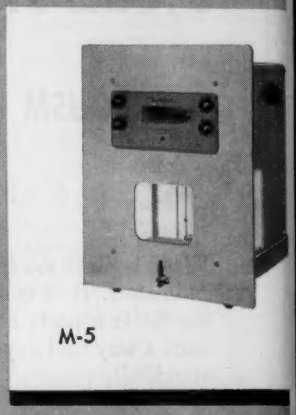

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